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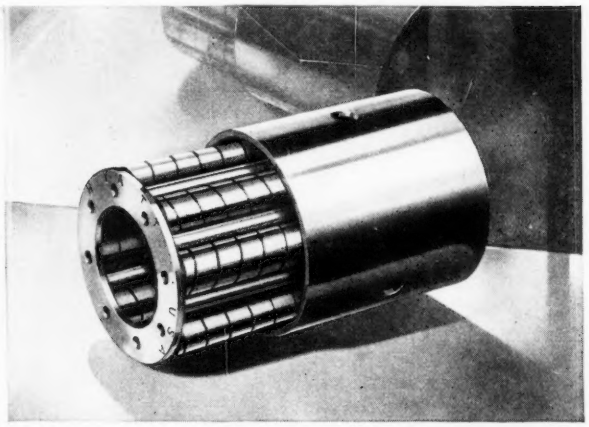
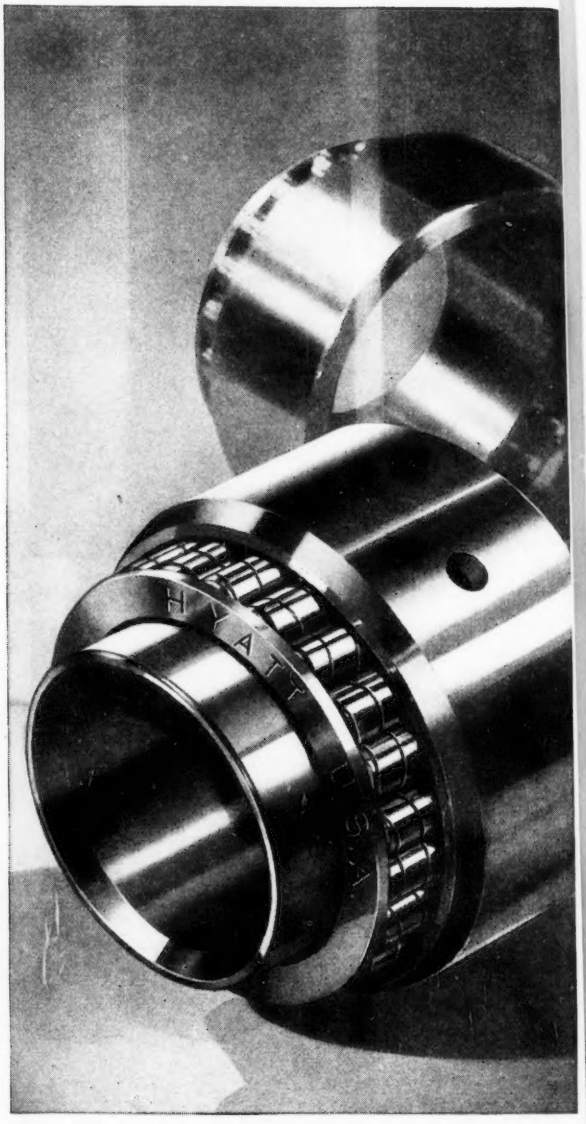


Illustrated at left, Hyatt Split Outer Race Bearings. Below, the Hyatt Standard Series Bearing.



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AGRICULTURAL ENGINEERING

Volume 14 JANUARY 1933 Number 1

The Challenge to Agricultural Engineers as Seen by a Farm Management Man[1]

By V. B. Hart[2]

THE AUTHOR makes no pretention to being either an engineer or an economist. He has, for a number of years, been engaged in farm management extension work in New York, the aim of which has been "to help farmers make more money." And let it be understood that the suggestions and recommendations he makes in this paper are simply the observations of a man in one subject-matter field who has been asked to look over the fence into another field and write down what he sees.

Three years ago when I met with this group, the general price level of the United States was approximately 40 per cent above pre-war. Indications then were that we were in a period of generally declining prices, and those indications have materialized into fact. We have now not only returned to a pre-war price level, but have gone about 5 per cent below. The index of prices of farm products in the United States, which three years ago was about 40 per cent above pre-war, is now nearly 50 per cent below. Farm prices here in the northeastern part of the country have not dropped as much as in the South and West, but even here in this more favored section they are now down to approximately 75 per cent of pre-war. Retail prices of farm machinery are about 150 per cent of pre-war, and farm taxes in this section of the United States are at least double pre-war.

There has been some drop in the cost of farm labor, but as near as I can ascertain farm wages in the states represented by this group are still from 10 to 20 per cent above pre-war.

All this means that here in the northeastern part of the United States, it takes twice as many farm products to buy a given piece of machinery as it did before the war, about 50 per cent more farm products to hire an hour of labor, and from two to three times as many products to pay the taxes.

There are three curves or combinations of curves referred to by your chairman in his opening remarks which, in my opinion, depict the present agricultural situation and give us a general background for future engineering and farm management programs. The first of these (Fig 1) shows the general wholesale price level of the United States.

The general price level of the United States has not only returned to pre-war, but has gone about 5 per cent below. Attention is called to the great similarity between the declines of the general price level following the World War, the Civil War, and the War of 1812-14.

Farm prices have not only followed the general price level down but have also gone still lower. This has not, however, been due to overproduction. From 1839 to 1900, the per capita production of food and feed crops in the United States increased at the rate of a little less than 1.0 per cent per year, and then from 1901 to 1930 decreased at the rate of 0.2 to 0.3 per cent per year. It is difficult to see how the agricultural depression can be attributed to overproduction when per capita production is declining for the first time in history.

When the general price level takes a big raise or a big drop, wages tend to lag behind, i. e., are slow to rise when prices of other things are going up and slow to come back into adjustment when the prices of other things are going down. (See Fig 2.)

Freight rates and other handling charges are made up so largely of wages that distribution charges on farm products follow the trend of wages and are now about 150 per cent of pre-war. (See Fig 3.) The farm price is always the retail price less the cost of distribution. With distribution charges 50 per cent above pre-war, there is a larger than usual slice taken out of the retail price before the farmer gets his share.

This lag in wages and the consequent lag in distribution charges is the reason why retail prices are relatively high as compared with farm prices. The farmer who is in position to sell most of his products at retail is in a very preferred position compared with the farmer located at a greater distance from market. This is the reason why there are less mortgage and tax sales in the Hudson Valley and southern New England than in western New York and Pennsylvania. The difference between being able to sell at retail or wholesale has probably been responsible for changing the political views

One way of increasing the production per hour of labor is to increase the use and efficiency of modern labor-saving machinery

[1]Paper presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers held at the Ten Eyck Hotel, Albany, N. Y., in October 1932.

[2]Department of agricultural economics and farm management, New York State College of Agriculture.

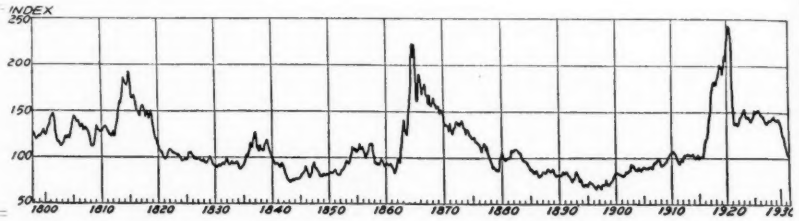


Fig 1. This curve shows the general wholesale price level of the United States for over 130 years—1798 to 1930. This curve served as a general background for future agricultural engineering and farm management programs, says the author

of more farmers than all of the speeches made during the past summer.

The trend of the general price level is what is going to make or break many farmers. Engineers, economists, and farm management specialists do not all agree on what is going to happen to the general price level. I happen to belong to a group that believes the cause of present low prices is a monetary one, and that there is a direct relation between the world monetary stocks of gold and prices. Time will not permit the presentation of facts to substantiate this view, but it can be said that those persons who have held it are the only ones who, with any degree of accuracy, predicted the movement of the general price level that has occurred since 1920.

I, therefore, advance the following opinion concerning the future trend of prices: "Unless there is a sudden discovery of some great supply of gold, or unless countries now off the gold standard cease to bid for gold and thus reduce its value, or unless the United States reduces the amount of gold in the dollar, or takes similar action, indications are that we can expect a general price level of pre-war or below. The safest procedure for a farmer to follow is to expect the continuance of pre-war or below pre-war prices. Then, if some monetary change is made, or large amounts of gold are discovered, he will be that much ahead."[3]

With such a picture of where we are, and perhaps something of a glance ahead, just what are some of the things that the farm management worker sees in the engineering field? In the 1932 New York State Agricultural Outlook, prepared by the author and others of his staff last winter, this statement appeared: "The most important adjustments needed in New York agriculture are those of reducing costs of distribution and of producing farm products with less hours of labor."[4] The same could have been said for all of the northeastern part of the United States, and that statement is still true as a general long-time proposition. However, as I have attempted to point out, there is another more immediate and short-time problem added to the present farm picture, namely, getting enough cash to cover the absolutely necessary business and personal expenses.

The farm family is just naturally going to spend fewer dollars because there are fewer dollars to be spent, and both the agricultural engineer and the farm management worker must take this fact into consideration.

As I look over the present economic situation, and then look over the fence into the field of engineering, I see ten things on which I feel that the agricultural engineers in the land grant institutions must plan their programs of research, resident teaching, and extension. These ten things are:

1. Low general price level
2. Labor relatively high
3. Distribution charges high
4. Retail prices high
5. Machinery and equipment high
6. Cash repair costs high
7. Conservative credit policies
8. Interest and debt payments high
9. Taxes high
10. Less cash to be spent.

If these ten things are the agricultural-engineering outlook, what are the engineering and farm management adjustments that we should help the farmer make to meet them? Let us consider them in the order given.

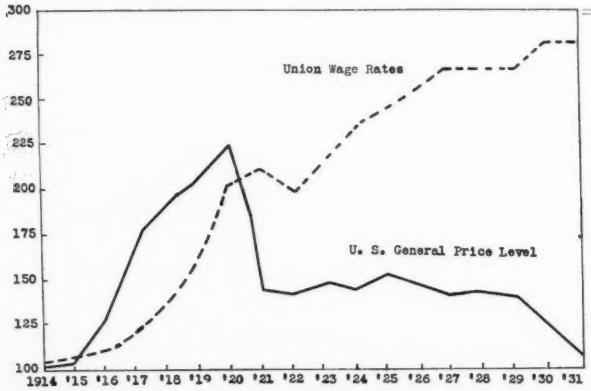
1. Low general price level. Doesn't that mean that, if we are to expect to continue on a pre-war price level, or below, that if we make any investments in buildings, equipment, or machinery, at more than pre-war prices, we may have to take an extra depreciation on our investment?

Prices of farm land have gone back to pre-war, but costs of erecting farm buildings are still much above pre-war. The farmer in the northeastern part of the United States who builds a new set of barns at present prices, should be very sure that he has a special market for his product or that he can produce it with more than average efficiency. The agricultural engineer or farm management specialist who advises a farmer to build a new set of buildings should remember two things: first, the probability of our continuing on a pre-war or below pre-war price level, and, second, that the farmer is not going to forget who advised him to do the building.

2. Labor relatively high. This means that there is still a great need for saving on labor by increasing the

[3] "Much Gold—Much Price," What Are the Facts, II. Published by Extension Service of New York State College of Agriculture in Farm Bureau News Service, October 1932.

[4] The New York State 1932 Agricultural Outlook, Cornell University Agr. Exp. Sta. Bul. 227, p. 3.



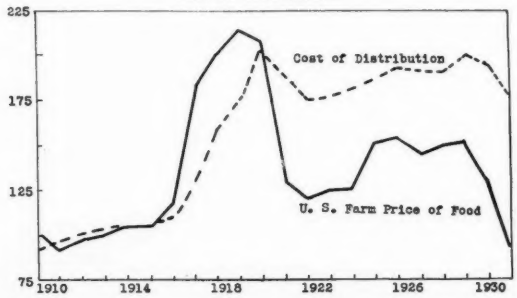


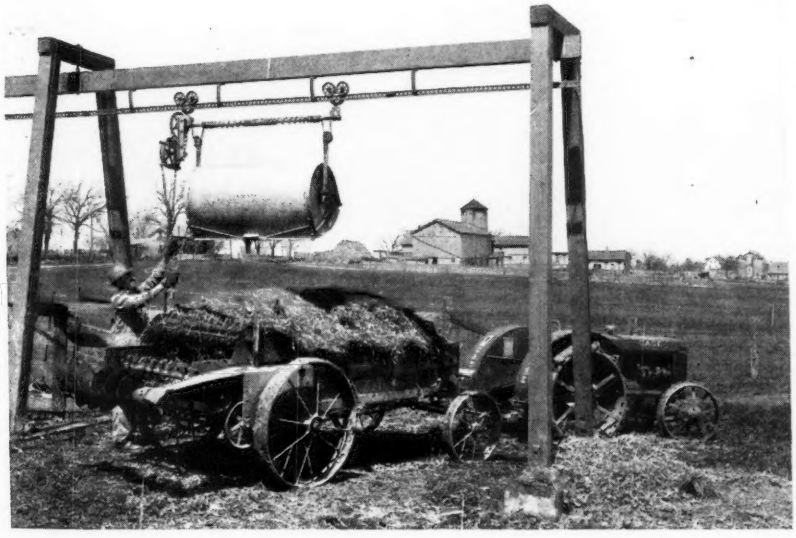
Fig 2. (Left) When the general price level takes a big raise or a big drop, wages tend to lag behind. Fig 3 (Below) The farm price is always the retail price less cost of distribution

production per hour of labor. One of the easiest ways of doing this is to increase the production per animal and per acre, and the first step to take in this direction is to abandon the poor producing acre and the poor producing animal, and to give better care to the good ones that are left. Fertilizer and lime are cheap compared with labor. We can expect to see more commercial fertilizer and lime used on our good land. As agricultural engineers, you may expect to be called upon still more for efficient and cheap equipment for applying lime and fertilizer, and especially for help in repairing the old lime sowers and fertilizer-distributing attachments now on hand.

One way of increasing the production per hour of labor is to increase the efficiency of machinery. I will not burden you with any more charts or figures, but it is a well-established farm management principle that one of the most important factors affecting the cost of machinery per acre is the size of the business or number of acres on which the machine is used. With farm machinery prices 50 per cent above pre-war, and prices of farm products 25 per cent below, a man must have more business than formerly to warrant owning a given piece of labor-saving equipment. Those of you who are selling—or attempting to sell—farm machinery need to keep this in mind. For both his own good and that of the farmer, the salesman had better try to show the farmer how to increase the size of his business enough to warrant owning a machine rather than selling him something for which he does not have sufficient use, and for which he will not be able to pay.

One way of increasing the efficiency of machinery is by making sure that it is in shape to give more service. We need still more schools and short-courses on putting machinery into condition so that it can cover a larger number of acres before wearing out or breaking down. The agent who sells a farmer a machine or a piece of equipment needs to plan on giving him about twice as much in the way of instruction and initial service if he expects the machine to last until the note is paid.

3, 4. Distribution charges high, retail prices high. That means more retailing of farm products and more direct buying of farm supplies. By retailing his own products, the farmer gets a little slice of those high-distribution charges, and by buying at wholesale he eliminates high handling charges on incoming supplies. Farmers are going to need more instruction in building and equipping delivery trucks and wagons, and especially in the building and equipping of roadside stands.



In his efforts to get to market the farmer wants a good road but he also wants lower taxes. One place where the agricultural engineer may be going to fit into the picture is by showing farmers and rural highway superintendents how to build and maintain inexpensive roads with local labor and materials. In this respect we have not advanced quite as far as Julius Caesar had when he was conducting his campaign in Britain a couple of thousand years ago. He had practical and experienced road builders to superintend the construction of his highways. We have either Republicans or Democrats.

5. Machinery and equipment high. I have already mentioned several adjustments needed to meet high costs of machinery and equipment. In addition I would reemphasize that of paying cash and getting the discount. Cash is scarce in the farmer's pocket. It is also scarce in the pockets of the dealer and manufacturer, and merchants and dealers are giving more liberal cash discounts than ever before. Therefore, as engineers, after you have figured out how much a farmer would save by having a certain piece of equipment, get your slide-rule out again and figure how much interest he is paying if he buys the machine on the instaliment plan or gives a note for it, instead of paying cash. Then tell the farmer to take the figures to his banker and see if he cannot, by filing a credit statement, get his credit where it costs him less than from the merchant or dealer.

Many farmers are getting tired of having to pay for a part of their neighbor's credit, and for the cost of having a salesman convince them that they want to buy something. Therefore, they are frequently forsaking the local dealer or agent and buying elsewhere. We can probably expect to see more mail-order buying. Some dealers in farm supplies are anticipating this situation by giving mail-order service.

6. Cash repair cost high. This means more home-repair work. A few years ago we were warning farmers about spending a dollar's worth of time in making an article that they could buy for 50 cents. Right now we should encourage the use of farm labor, farm lumber, and farm scrap iron to save cash expenditures. I recently saw a pair of whiffletrees that a man made from lumber cut on his own farm, and from old wagon tires and iron rods from the junk pile out back of the barn. It took him more than a full day to make the set, but, as he said, it didn't mean spending a cent of cash.

Many of our younger farmers have never learned to do some of the manual operations in which our fathers and grandfathers were skilled. Knowing how to do these might now mean making use of home labor and home supplies, and the saving of cash expenditures. There may be some danger of encouraging farmers to spend too much labor in order to save a little cash, and the time will undoubtedly come when we shall again need to warn them about spending that dollar's worth of time to save buying a fifty-cent article. But there is probably more danger at the present time of not giving them enough help on their home-repair and construction work than of their carrying this type of economy too far.

There is a decided need for helping farmers to relearn how to make a whole lot of different things that they have been buying, and to make these with the minimum amount of tools and time. This applies especially to doing some of the skilled-labor jobs, such as plumbing, electrical work, concrete work, pipe fitting, etc. The agricultural engi-

neer has done a splendid job in showing the farmer how to put in water systems, pour concrete, and wire buildings, but during the past few years many farmers have been able to raise the cash to hire someone from town to do these jobs for them, and have not learned how to do them themselves. This means a still bigger extension job than ever before for the agricultural engineer. We may also have to scale down some of our ideas and recommendations to check with the amount of cash that the farm family has for spending. The man who has attended an extension school and learned how to put in a pressure water system, may at the present time need advice on how to repair the old-pitcher pump, so that it will serve for another year.

Indications are that the demand for the services of engineering extension specialists for tractor schools, gas engine schools, etc., are going to far exceed the help available. This means that more farmers must be taught to do these repair jobs entirely on their own.

In addition to the need for more instruction on the care and repair of general farm equipment, there is also a new need for giving instruction in some of the more prosaic lines such as cobbling shoes and repairing rubber boots. Many of our farmers have learned at an extension school how to lace a belt and time an engine, but right now they will either have to know how to put on a pair of half soles or else someone will go barefoot. It is true that some of these manual operations take a lot of time, and in many cases if the time were figured at ten cents per hour it would on paper look like poor farm management. However, the fact remains that our farmers are going to be doing some of these jobs, and if they are going to do them, we should help them to do them in the most economical way possible.

7. Conservative credit policies. Banks are more than ever particular to whom they loan money, and dealers are loaded up with farm paper. Probably the best ways in which the agricultural engineer can help on the credit situation are, as I have indicated previously, by encouraging the use of bank credit, instead of store credit, and by discouraging the use of credit for the purchase of equipment for which there is not sufficient use. Merchant credit is more expensive than ever before, and it just naturally takes a bigger volume of business to warrant the owning of a given piece of machinery than it did when equipment prices were more in line with the prices of farm products.

8, 9. Interest and debt payments high, and taxes high. This simply means that from the standpoint of the agricultural engineer there is going to be less cash available to be spent by farmers for new equipment and buildings, and for the repair of equipment and buildings now on hand.

10. Less cash to be spent. This last statement is the one on which our agricultural-engineering program must be based

In spite of the popular statement that farmers are not in a mood to read bulletins and to listen to lectures and discussions, the demand from farmers for technical information is greater than ever before. The only change in the farmer's attitude in respect to wanting information that I have been able to note in the past year, is that he wants more of it, wants it sooner, and is especially anxious for the kind of information and advice that will help him to get enough cash to cover his absolutely necessary business and personal expenses, and this last want is the challenge of the times to the agricultural engineer that the farm management man sees as he looks over the fence into the field of engineering.

Sources of Ultra-Violet Radiation[1]

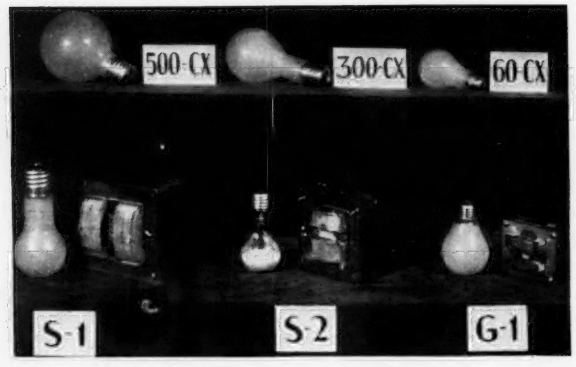
By B. P. Hess[2]

THE need for efficient and simple sources of ultra-violet radiation has led to the development of various "sun lamps," shown in the accompanying illustration. All of these are of course equipped with special glass bulbs capable of transmitting ultra-violet radiation. Aside from the mercury vapor tubes, which have been on the market for some time, the Type S-1 sun lamp is the most powerful of these new sources. The Type S-2 sun lamp, of the same general characteristics, meets the demand for a source of lower wattage and lower cost. The Type G-1 lamp, also a low-wattage source, differs from the S-1 and S-2 lamps in that it gives very little visible light. The Mazda CX lamps, available in three sizes, are essentially high efficiency Mazda lamps with the special glass bulbs transmitting ultra-violet radiation.

The S-1 and S-2 lamps require transformers, while the G-1 lamp requires a reactance. The Mazda CX lamps operate direct from the line. The following table affords a general comparison of these sources:

[1]Abstract of a paper presented at a session of the Rural Electric Division of the American Society of Agricultural Engineers during the 26th annual meeting of the Society held at Ohio State University, Columbus, in June 1932.

[2]B. P. Hess, rural electrification, Westinghouse Electric and Manufacturing Company, Pittsburgh.



"Sun lamps" recently developed as sources of artificial ultra-violet radiant energy

	S-1	S-2	G-1	60 CX	300 CX	500 CX
Relative ultra-violet output	100	20-25	8-15	0.4 - 0.6	2 - 4	5 - 7
Wattage (including Auxiliary equipment)	450-500	175	45-50	60	300	500
Relative ultra-violet per watt	100	55-65	85-140	3 - 5	3 - 6	5 - 7

An advantage of the lower wattage sources, such as the G-1 and 60-w Mazda CX lamps is that the lamps operate at a low temperature, and in poultry work the birds can be close to the lamp. On the other hand, the lower output of ultra-violet radiation of these sources necessitates longer exposure for equal irradiation.

An Improved Method of Irrigation Canal Maintenance

By C. J. Gronland[1]

IRRIGATION canals have a tendency to become overgrown with weeds and brush, which decreases the canal section and hinders the normal flow of water. Keeping these canals clean so that they can function efficiently is always a problem. The canals must be kept clean for neglect results in decreased carrying capacity.

The Fresno Irrigation District consists of 241,000 a in Fresno County, California. To divert water to these lands there is within the District approximately 1200 miles of canals. Approximately 600 miles of these canals are main canals and main canal laterals, varying in size from 5-ft to 60-ft bottoms and carrying from 10 cfs to 1200 cfs. These 600 miles of canals are operated and maintained entirely by the District. There are approximately 600 miles of smaller canals, the so-called farm laterals, which are operated and maintained mostly by the water users.

PREVIOUS MAINTENANCE PRACTICE

There are several methods by which these canals may be kept clean. One is to clean the canals in the fall of the year or during the non-operating season. A few years ago this method was used entirely. There was not much thought given to levee maintenance, the work being done in or from the water channel when the canals were dry. Consequently the levees became overgrown with brush and weeds which hung into the water channel in many cases closing the channel entirely. The banks were practically inaccessible.

The first operation in cleaning was to cut this overhanging brush and weeds with scythes, mattox, and axes. After the weeds and brush had been cut, they were either forked out or burned.

The cutting and burning of the weeds and brush in the fall is difficult because they are wet either from frost, dew, rain, or fog. If the brush will burn, it is a terrific fire hazard on account of the adjacent personal property which may consist of fences, corrals, barns, fruit trees, grape vines, etc.

The overhanging brush from the levees catches the silt which is always present in the water, causing berms to form on the sides and bottoms of the canal, decreasing the area and therefore the carrying capacity. These berms are removed either by shoveling or scraping, the banks being inaccessible to equipment. Where scrapers are used runways are cut through the debris on the levees and the berm material deposited outside the canal levees behind the brush. After the work, as indicated here, was done the canal water section was comparatively clean for several months, mostly during the non-operating season. It was obvious that this system of maintenance was not entirely satisfactory. It only gives a clean canal part of the season and does not eliminate the cause of the troubles of maintenance work. To properly maintain the canals, the levees should be maintained because a large percentage of the water section trouble arises from the weeds and brush hanging over the banks into the water. It decreases the velocity of water and, as stated before, causes heavy berms to form by the silt adhering to the broken down brush and growing weeds and grass.

Typical condition of an irrigation canal before the equipment referred to in the accompanying article by Mr. Gronland was used

Side and bottom of irrigation canal after use of equipment, showing that maximum capacity of the canal has been made possible

PRESENT MAINTENANCE PRACTICE

It was evident that a program of maintenance during the twelve months would greatly increase the efficiency of water service to the water user, as compared to a program of work on the canals during the fall months only, because the canals would be kept clean during the operating season and prevent the great loss of water due to unclean canals. This change necessitated the clearing of levees so that they could be maintained the year around. These cleared levees are mowed with horse-drawn mowing machines during the months from April to September, inclusive. The levees are mowed twice a year, the first mowing being completed about July 1 and the second about October 1. After the second mowing the weeds are burned.

This method not only gives clean banks throughout the year but it decreases the canal section work later, because of the decrease of berms. It also controls the spread of noxious weeds by cutting them before they go to seed. (Irrigation water is one of the chief sources of spreading weed seed.) This method of having clean levees throughout the year decreases the maintenance of the canal water section during the non-operating season because of decreased berms caused from overhanging weeds.

Although there is a great decrease

[1]Superintendent, Fresno (California) Irrigation District.

Two views of the equipment used in the Fresno (California) Irrigation District for rebuilding irrigation ditches. (Left) Shaving off the weeds and remodeling the bank of an irrigation ditch. (Below) The old canal was 16 ft wide, was shallow and irregular, silted badly, and encouraged weed growth. The new canal is 8 ft wide, and is straighter, deeper, and easier to patrol

of berms in the canal water sections, due to clean levees, there is, however, a natural annual accumulation. This accumulation is in the bottom of the canal section where the slopes and the bottom join, the canal section being more or less rectangular with side slopes with ¼ to 1 to ¾ to 1. This accumulation is removed by first plowing it away from the side of the canal bank. This requires two rounds with the plow. After the plowing a "V" is hooked onto and the plowed material pushed where it can be removed from the canal or spread out with scraper teams. The scraping operation has been simplified because the levees are now clear, allowing teams to make exit easily from the canal.

In 1929 the District experimented with tracklaying tractors and trailor graders in levee maintenance. The levees were cleared, the grader cutting just below the surface of the ground. This cut the weeds and disposed of them at the same time. This operation flattened and improved the levee, creating a smooth, clean levee which has resulted in a valuable canal maintenance feature. This experiment proved that where grader equipment could be used. it was far better for canal levee maintenance than any method used to date. It practically eliminated the mowing and burning of the levees, there being nothing to mow or burn after grading.

There has been no more trouble with the adjacent property owners on account of fire damage to their orchards, vineyards, or property in general. Grading controls the spread of noxious weeds because they are eliminated before going to seed.

It has been found that the grader is more efficient than the plows and "Vs" of the previous system in canal section work. The tractor pulling the grader in the bottom removes the berm and spreads it in one operation, where the plows and "Vs" involve five operations.

If the side slopes in the canal section are not continuously or annually bermed, the ¾ to 1 slope finally becomes perpendicular because the silt that is always in the water adheres to the weeds on these slopes. Obviously the canal section area is considerably decreased, and the slopes must be removed back to the ¾ to 1 slope. To do this it requires either a very heavy operation using teams and plows, or the use of dragline dredgers. To prevent these side slopes from becoming perpendicular from the accumulation of silt, the tractor and grader are again put into use. The grader blade is tilted to the slope and cuts off the annual accumulation, thereby holding the required slope and the proper water section area.

In conclusion, from our experiments, it seems evident that the use of tractor and grader equipment in irrigation canal maintenance will be more extensively used because levees can be graded during the operating season, keeping them clean the year round, thus controlling the spread of noxious weeds, and preventing the damage by fire to adjacent property. During the non-operating season when the canals are dry the annual accumulation in the bottom can be worked better and more economically, and the side slopes can be maintained and kept clean.

Stream Control by Barriers

TO PREVENT quantities of sand, gravel, and heavy debris from being washed into irrigation canals by mountain streams at flood periods, a system of stream control by barriers consisting of embankments, a spillway, and a control basin, has been devised by the U.S.D.A. agricultural engineers.

The barrier is constructed at a favorable location in the stream so as to spread the water and cause the material to be deposited in the basin. As the basin becomes filled, the stream is so directed that the burden it drops builds the embankments higher. The embankments and spillway may be made of materials at hand—of timber and rock, rubble masonry, or rubble-concrete.

Control works have been installed on 18 streams in Utah, and recent studies indicate that the supply of irrigation water from those streams has been doubled and the expense of cleaning canals and ditches reduced.

The Development and Use of Roofing Nails[1]

By A. J. Deniston, Jr.[2]

IF A GOOD GRADE of roofing is applied with a bright or polished steel nail, the roofing will not last long, for within a comparatively short time this bright nail will rust away at the shank—underneath the head—and the holding power of the nail, which keeps the roof in place, has been lost. The result is that the roof will begin to leak, moisture and frost will start to attack the roofing material at the nail hole causing it to disintegrate, and a new roof will soon be necessary. Now, if this same roof had been laid with a good grade of galvanized or rustproof nail, which can be secured at only a slight extra cost, the roofing material would have given many more years of service. Every farmer knows that bright steel will quickly rust when left outdoors, yet even today large numbers of roofs are laid with bright steel nails.

Man has striven for years to improve upon roofing materials with the following objects in view: (1) To secure a material which would withstand the elements and give longer life, (2) to manufacture a type of roofing which would be fireproof, and (3) to produce a low-cost roofing material which could be easily applied. To the unprejudiced mind, one of the best roofing materials which has been developed for use on farm buildings, every phase of the matter being duly considered, is galvanized sheet steel roofing. This statement is substantiated by a large number of farmers who have had actual experience with many kinds of roofing.

Sheet steel roofing is 100 per cent waterproof, but in order to lay it, it becomes necessary to puncture it full of nail holes. Approximately 100 nails are used per square of roofing (100 square feet). Driving a nail through sheet steel roofing makes a depression in the sheet around the nail hole; it makes a rather ragged hole very much like sticking the point of a pencil through a piece of paper; it chips or breaks the galvanizing off around the nail hole, leaving a varied area of bright steel exposed.

Almost at the inception of the use of sheet steel roofing in this country, lead washers were used under the heads of nails when fastening the sheets in place. The object was to have the washer underneath the head so that the lead would fill up the depression in the sheet, to plug the hole and make it watertight, and to have the lead cover the broken area around the nail hole where the galvanizing chipped away. Unless the sheet is effectively covered where the galvanizing breaks, corrosion will soon attack the steel, and the sheet will rust away from the nail, with resultant loosening of the sheet.

In the accompanying illustration is shown (both in full view and in cross section) the advancement in the use of lead on nails for roofing purposes. Each nail has been accurately drawn to size as it is manufactured.

The first, A, is the loose lead washer and nail, showing clearly the use of lead under the head of a nail which should, first, seal the hole, and, second, cover the break in the galvanizing around the nail hole, the only real reasons for putting lead on nails.

The nail B represents the first improvement over the loose washer and nail and is one of several lead-head nails of this general type which are manufactured. This nail has the lead cast completely around the steel head of the nail. As the inventor was an actual user of lead washers, he knew it was necessary to have the lead under the steel head of the nail, but the only way he could cast the lead under the head, and hold it there, was to cast it completely around and over the top of the head of the steel nail.

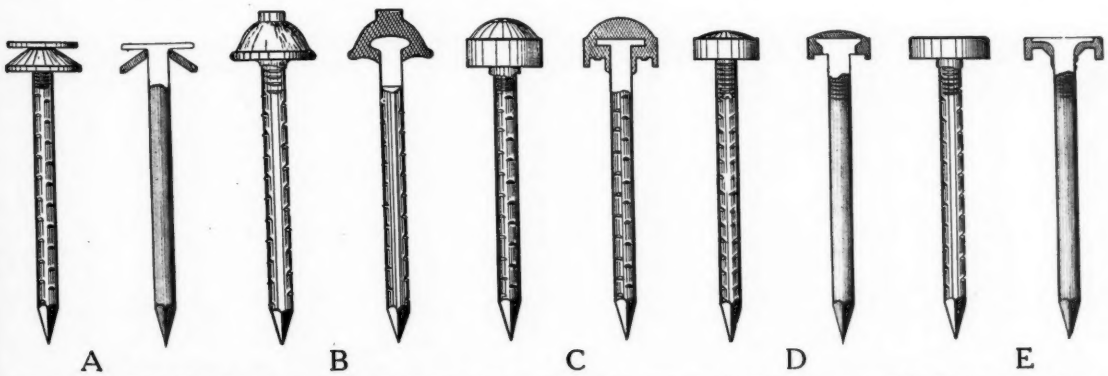
Lead is a very soft metal, and when driving a nail of type B, the hammer hits directly upon the lead head. Each blow tends to flatten the lead and break it away from the steel head of the nail, and there is always the possibility of driving the lead completely off of the head when the nail is driven down into the sheet.

Nail C has the same construction as type B, inasmuch as the hammer strikes the soft lead head when driving the nail. This nail, however, has lead extending down the shank of the nail, which is intended to more effectively plug the nail hole. It will be noted, also, that nail C has a flange around the periphery of the lead head, which extends downward and forms a cup shape under the head, while on nail B the flange extends outward. The purpose of the flange on each nail is to cover the sheet around the nail hole where the galvanizing breaks away.

Nail D is quite different in construction from nails B and C, and is manufactured by pressing cold lead over the head of a specially designed steel nail. This steel nail has a shoulder under the head which, in the process of manufacture, supports the nail in the die while the lead is being forced down over the head. The lead, therefore, comes flush with the underside of this steel shoulder but does not cover it, and there is no lead around the shank of the nail to seal the hole, as there is in all other types of lead head nails. When this nail is driven down into a sheet, it can easily be seen that this shoulder on the nail will make a steel against steel contact at the

[1]Paper presented at a meeting of the Structures Division of the American Society of Agricultural Engineers held at The Stevens, Chicago, November 1932.

[2]Owner, The Deniston Company. Assoc. Mem. A.S.A.E.



Five types of lead-head nails used for galvanized sheet steel roofing. The illustrations are accurately drawn as to size and proportions, and the nails are shown both in full view and in cross section

nail hole and that the lead head will cover a smaller area on the sheet around the nail hole, where the galvanizing chips off, for the diameter of the head is somewhat reduced in comparison with other lead-head nails.

It will again be noted that, in the actual use of nail D, the hammer must strike the soft lead head. While the lead on this nail is compressed, it is, nevertheless, lead, and lead is very ductile and soft whether it is cast, drawn, extruded, or compressed.

In the use of any nail which has lead over the top of the head, there is always the possibility of knocking the lead head completely off, or of driving the steel nail head out of the lead. When such nails are driven home, it cannot be determined how much lead has remained under the head, for the pounding on the head causes the lead to spread out and away from the steel head of the nail. There is always the possibility that just one more blow will knock the lead head completely off the nail.

Nail E reverts back to the first principle in the use of lead on nails—the lead washer—and to where the blows of the hammer are directly applied to the steel head of the nail. The head is so designed that the lead comes flush with the top surface of the steel nail head and forms a heavy downward flange around the periphery of the lead head, which will conform to the shape of the corrugation in the sheet, and effectively cover and seal the break in the galvanizing around the nail hole. The hammer blows will drive the lead downward at the same time the nail is being driven downward. On other types of lead-head nails, as the nail is driven the hammer blows tend to force the lead away from the nail as it spreads out.

Nail E has the lead under the head and extending down and around the shank of the nail in such design that the lead will completely fill the depression in the sheet and actually plug the nail hole with lead. The harder this nail is driven, the tighter it will seal, for the lead will be driven farther and farther into the hole, and the lead can never be knocked off or distorted to where it would not serve its purpose. Because the hammer strikes the steel head of nail E, it can be driven through two and even three thicknesses of ordinary steel roofing, where the sheets lap each other, without first punching a hole through the sheets. This effects a saving both in labor and nails because the lead head cannot be knocked off.

Lead-head nails of the cast type (B and C) cannot be manufactured in a hot-galvanized finish. For this reason bright steel nails having lead heads have been used for years. Roofing nails never rust away from the top of the head down, but they rust away underneath the head, on the shank of the nail, and especially at the point where the nail enters the wood; very much like a fence post will rot away at the ground level. Dampness and moisture get to the shank of a nail from underneath the sheet, and a bright nail will rust under the sheet no matter how well the nail hole is sealed. Therefore, whatever type of "lead-head" a nail might have, it is logical that all galvanized sheet steel roofing should be laid with a good grade of galvanized lead-head nails.

By using a heavy zinc-coated nail which has a lead head so designed that the lead will fill the depression, plug the hole, and cover the break in the galvanizing, a sheet steel roof will give maximum service. Heavy coated sheets, such as those meeting the "Seal of Quality" standard, if laid with this type of nail, should last a lifetime on any farm building.

The American Zinc Institute has made an extensive study of the use and application of sheet steel roofing and in its specifications for approved types of nails for laying corrugated galvanized roofing appears this statement: "All nails should be heavily zinc-coated to protect them from rust. Use lead washers with all nails not made with lead heads; . . . the soft lead should fill the hole around the nail to prevent leakage and rusting of the sheet at that point."

Only nails D and E can be furnished in a hot-galvanized (heavy zinc-coated) finish, and of these two only nail E has the lead under the head so that the lead will actually fill the hole around the nail.

While nail E was originally developed for applying sheet steel roofing, it has been found an excellent nail to use for laying prepared roll roofing, metal shingles, tile and slate roofing. Nails for slate roofing, however, are made from pure copper nails.

The cost of nails necessary to lay a roof of any description is a very small item in comparison to the cost of the roofing material. For instance, enough nails of type E to lay a square of roofing would cost approximately only 20 cents. This small cost in the initial investment of the roof is many times repaid by the added years of service and maximum life the roof will give.

You have heard the old expression, "A chain is no stronger than its weakest link." So is a roof no better than its weakest point, and the failure of roofs of every type, in the majority of cases, can be directly traced to the bright roofing nail having been used, or an inferior grade of galvanized nail which quickly rusted away.

RECOMMENDED PRACTICE IN THE USE OF LEAD-HEAD ROOFING NAILS

1. Always use a hot-galvanized nail
2. Use about 100 nails per square of roofing
3. Use the longest nail possible to secure the greatest holding power
4. The length of nail depends upon the under-construction of the roof, whether it is 1-in wooden strips or two-by-fours
5. Use 1½ or 1¾-in nails to lay 1¼-in corrugated sheets on new building, depending on under-construction
6. Use 1¾ or 2-in nails to lay 2½-in corrugated sheets on new building
7. Use 2 or 2½-in nails to lay sheets over old roofs
8. At the top and bottom of sheets nail through every other corrugation; along the sides nail every 6 to 8 in
9. On 1-in wooden strips it is recommended to use nails long enough to drive through the wood and clinch from underneath
10. The longer the nail and the greater number of nails used, the more securely the roof will be applied.

NUMBER OF NAILS TO THE POUND

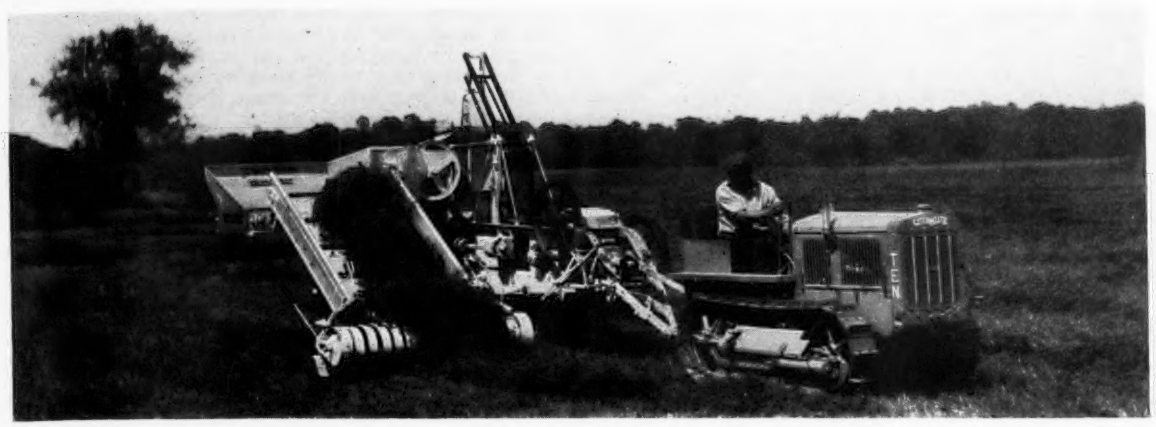
Length of nail	1½ in	1¾ in	2 in	2¼ in	2½ in
Bright	93	85	81	74	70
Hot-galvanized	90	83	77	73	69
Pure copper	90	83	77	73	69

Engineering in Agriculture

By Charles E. Seitz

THE great progress that has been made in the development of farm power and machinery, in the control of soil erosion, in the drainage, irrigation, and clearing of agricultural lands, in the application of electricity to agriculture, and in the development and improvement of farm structures, has largely been brought about through the efforts and activities of engineers.

In a broad sense engineering means to agriculture essentially what it means to manufacturing. The industrial preeminence of this country is largely an engineering preeminence. We are now witnessing a development in the application of engineering to agriculture comparable to that which began to get under way in manufacturing and transportation about fifty years ago. In the final analysis engineering in agriculture makes possible the lowering of production costs. This in turn is the surest road to larger profits, and consequently to higher living standards.



The picture shows the Ann Arbor hay and straw combine, or pick-up baler, in operation

Development of the Hay and Straw Combine[1]

By L. R. Tallman[2]

WITH the increasing interest in the raising of legumes, particularly alfalfa, came the call for a machine that would combine two or more harvesting operations into one, and at the same time prepare the crop for market with a proportionate saving in labor and costs; a machine that would enable the farmer to realize his ambition of greatly increasing his alfalfa acreage, but with less interference with the tending of his other crops during the harvesting of three or more cuttings per year; a machine to take to the crop instead of moving the bulky crop to the machine, and thereby provide the only means of retaining practically all of the leaves on the stems as well as keeping the hay free from dust and dirt by eliminating the necessity of dragging it over the ground.

As an example of the farmer's great appreciation of the application of combine methods to harvesting and preparing crops for market, reference is made to the comparatively recent crossing of the continent from the West to the East in the general adoption of the grain combine.

One resisting problem remained to be solved in that a vast percentage of the farmers refused to waste their straw. This proved the deciding factor as to the justification of the time, effort, and expenditure that would be involved in the pioneering of an entirely new type of agricultural machine that would automatically pick up forage crops from the windrow and prepare them for market in one operation, for in the salvaging of this straw it is only necessary to disconnect the drive to the straw spreader of the grain combine to permit the straw to be dropped on the stubble in perfect windrows.

This machine, now perfected, provides the only practical means of salvaging straw left in the field by the grain combine at negligible cost, and at the same time leaves it in the bale ready for market or for most economical storage and convenience in handling.

In developing a successful pick-up baler, it is highly essential that the baling press unit possess the maximum in capacity and strength with minimum weight. It must be free of mechanisms which tend to produce vibration or throw it out of balance in operation. It should partially balance on a single axle with the forward end resting on the drawbar of the tractor in order to provide the shortest possible turning radius as well as to allow the pick-up unit to follow closely the contour of the ground. The frame which serves as the foundation of the entire machine must be amply trussed to guard against sagging as a result of the extra duties imposed upon it as a traveling field machine.

Even though the pick-up baler has an advantage over other types of traveling field machines, in that it ordinarily is operated on comparatively solid hay meadows, the problem of keeping total weight to a minimum is of utmost importance. Power must be provided for operating the machine either by means of a separate engine, or it must be transmitted from the tractor. A separate engine adds weight, cost, fuel consumption, maintenance, and depreciation. As but 8 hp is required for operating the machine, our engineers were quick to take advantage of the rear power take-off facilities now provided on practically all American-built tractors, and thereby pioneered the power take-off baling press, as well as the hay and straw combine.

The result is a complete machine that includes picking up and power transmission facilities which weighs 300 lb less than our heavy-duty, belt-power baling press which was developed many years ago for steam tractor power. As a further comparison, its total gross weight operating in the field is over 1,000 lb less than the average of 10 and 12-ft grain combines.

The balancing point of the conventional belt power baler, being so far forward of the center of the frame, presents somewhat of a problem in mounting on a single axle, especially in view of the fact that additional weight must be added still ahead in order to provide the means of transmitting power from the power take-off of the tractor. Our engineers solved this problem to a great extent by eliminating the belt shaft of the baling press, adhering to the same gear centers and attaching the drive pinion to one end of the cross shaft of the power take-off transmission and the balance wheel to the other, and at the same time eliminating the necessity of belts and pulleys. In addition to the important reduction of weight and number of parts as a result of this unique feature, the only shafts on the machine revolving at a speed greater than 220 rpm are carried on roller bearings.

In order to keep angularity of the universal joints of the drive shaft to a minimum, the height of the power take-off transmission should be in keeping with the average height of the power take-off outlets of the various tractors. The angularity of the universal joints is prac-

[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers held at The Stevens, Chicago, November 1932.

[2]General manager, Ann Arbor Machine Company.

tically fixed on a two-wheel machine, except in turning, whereas with a four-wheel machine it would at times be excessive in operation over uneven ground.

The principal problems encountered in the actual picking up of the windrow and conveying it into the hopper of the baling press unit in sufficient volume were those of carry-under, winding, breaking the hay stream for dropping the divider block with a minimum loss of time, and providing a positive means of again starting the flow of hay into the hopper of the baler after dropping the block. These problems were enlarged because of the necessity of handling different kinds of hay and straw with equal efficiency and under all conditions. Numerous features or mechanisms were tested which worked beautifully in the handling of one crop, but proved inadequate in another. The different types of grain combine pick-up units were thoroughly tested, but because of the broader requirements for the clean picking up of hay and straw alike from extremely short to long stubble, we saw fit to develop our own pick-up.

The pick-up should be somewhat wider than the actual spread of the windrow on the ground to aid the tractor driver in maintaining a straight course and still pick up all of the uneven edges. The pick-up on our hay and straw combine is 54 in wide, but it is capable of drawing in the scattered edges as far as 10 in on either side because of the absence of ground contact of any part in line with the ends of the pick-up cylinder, therefore giving in reality a picking up width of 74 in. It requires no more time to use at least normal care in making straight windrows of hay with the side-delivery rake, and the advantage gained is the same as that of following straight rows of other crops in cultivating. The pick-up should be balanced to the extent of permitting it to merely float along with practically no weight actually bearing on the ground. It must also be provided with a control within easy reach of the tractor driver and requiring but little effort for him to quickly raise it to a height of not less than 14 in in order to meet all requirements in turning and in transporting over uneven ground.

The first possibility of lodging or winding is immediately after the crop has been lifted over the pick-up cylinder, and as it is being passed on to the elevating conveyor. Next, at the top of the elevating conveyor the same problem is met on delivering the crop into the cross conveyor with the additional problem of avoiding carry-under. All of the various methods of conveying were thoroughly tried out including slats, canvases, etc., and a series of drag chains equipped with special tine links proved by far the most efficient for both the elevating conveyor and cross conveyor units. These same difficulties are presented again as the hay or straw passes from the end of the cross conveyor into the hopper of the baling press unit, but are entirely overcome by means of the drag chains. However, an entirely different method of stripping the tine links had to be adopted.

A problem of no small consequence was that of providing a force-feeding unit on which depended the success or failure of the machine as an absolutely automatic machine that would require no manual assistance except for wiring the bales. This unit must be equally efficient in working either forward or backward, and on it depends the quick separation of the hay stream for dropping the divider block as well as the positive starting of the hay again after the block is in place. Tines 5 in long literally reach out and pull the hay or straw in from above, and semi-compress it as it passes into the hopper of the baler, so that it will be kept well under the bottom of the feeder head and then strip straight out. These things presented some difficult engineering problems, but the outcome was a highly efficient device which accomplished all of the requirements with no possibility of winding.

Should the pick-up be ground-driven or power-driven? Early experiments were mainly confined to the ground drive off the right transport wheel and through a countershaft necessitating additional sprockets and other parts, together with several extra feet of drive chain. The idea was to recommend the removal of the combined pick-up and elevating conveyor unit for stationary baling (which can be accomplished by the removal of three bolts or pins), and pitch directly into the cross feed unit. It was soon discovered that the large area of the elevating conveyor offered outstanding advantages for receiving the hay or straw pitched or merely shoved onto it from stacks. In feeding from near the ground with the pick-up power driven, it is only necessary to push the hay or straw against or over the end of the pick-up cylinder. The adoption of the power drive added very materially to the capacity of the machine in stationary baling and entirely eliminated the need for at least one man. Sidedraft was also eliminated by relieving the transport wheel of the added rolling resistance involved in driving the pick-up. This importance is further emphasized by the essential location of the right transport wheel being some distance from the line of draft. An added advantage is gained in "gearing down" through the power drive instead of "gearing up" as is necessary when power is taken from the transport wheel.

The combining of the power drive for the pick-up into a single unit with the drive already provided for the cross conveyor was accomplished in a very simple and unique manner. It has the following duties to perform, all by means of a single control lever located in a position most convenient to the operator:

1. While picking up windrows the cross conveyor must be stopped and started at will in both a forward and reverse direction, but the pick-up must run continuously in the forward direction only.

2. For convenience in stationary baling, a small cam may be shifted permitting the pick-up to automatically stop and start with the cross conveyor, but the pick-up remains inoperative while the cross conveyor is operating in the reverse direction.

3. A backing-up clutch is provided so that the pick-up will not turn backwards under any condition.

Safety clutches are provided at all three points of power delivery, which insure against sufficient power being applied to spring or break any parts. An overrunning clutch is also built into the power shaft connecting the drive from the tractor to guard against the momentum of the balance wheel of the baler unit transmitting power through the tractor on closing the throttle.

The size shafting used throughout the entire machine, exclusive of the baling press unit, is 1⅛ in. These shafts operate at speeds of from 35 rpm to a maximum of 165 rpm, making it possible for all fifteen cast iron self-aligning bearings to be interchangeable.

It is possible for the running boards for the wire tiers to raise their entire length to a clearance of 17 in for transporting over uneven ground and irrigated fields.

No essential features have been overlooked, such as keeping the overall width within the limit for passing through 10-ft farm gates and for loading on flat cars so that only the two transport wheels and the pick-up unit would have to be removed in meeting the lowest freight rate requirements. The tread has been kept as narrow as possible for loading on motor trucks, as well as to offer no problems in transporting on concrete roads, the overhang all extending on the right side.

No disassembling or adjusting is required for transporting from one field to another.

Wind guards are essential in preventing the hay or straw from being scattered on windy days, especially as it is being conveyed up the elevating conveyor.

The push type of pressure lubrication is provided throughout.

Many tonnage records have been made with this machine that far exceeded our expectations, and we feel it is conservative to state that it is capable of baling double the tonnage with one-half the number of men as compared with any other method of baling from the windrow.

Application of Ultra-Violet Radiation in the Poultry Industry[1]

By Kirk M. Reid[2]

COMPETITION is active in the poultry industry, and in order to make a reasonable profit the natural seasonal and producing habits of poultry must be correlated with the seasonal demands and prices for birds and eggs. The objectives in the poultry business are: (1) the greatest possible egg production at times when egg prices are the highest, (2) rapid growth of pullets, (3) maximum hatchability, (4) freedom from disease, and (5) minimum production costs.

It is now known that these objectives can be materially aided by an ample supply of vitamin D in the systems of the chicks and hens. This is because vitamin D enables the system to assimilate minerals, and to build up calcium and phosphorus in the body; the lack of it results in the slow growth of chicks, weak bones, and the loss of many chicks by rickets. When the mother hen has an ample supply of this vitamin D in her system, enough of it is carried in the yolk of the egg to last the baby chick for a short time after hatching. However, when that supply is exhausted, a new source must be created and a sufficient amount continually supplied to enable strong healthy growth and freedom from disease.

There are two common methods of supplying vitamin D to poultry. One is to give the chick food which contains some material rich in that element, such as cod-liver oil; the other is to expose the chick to sunlight or its equivalent. Summer sunshine contains ultra-violet radiant energy which is absorbed by the chicken's body and converted into vitamin D. This seems to be nature's way of providing this necessary element. It is the method to which birds have become accustomed through countless generations of development, and they have, therefore, adapted themselves to use it to maximum advantage. Vitamin D obtained through the stomach will prevent rickets, but it does not seem to be as effective or as stimulating as that obtained from direct sunlight or its equivalent.

In the days when all poultry ran out-of-doors, natural sunlight was sufficient; the farmer of today, however, wants to raise his chicks before the weather gets warm. To do this the chicks must be raised indoors and usually in relatively confined quarters. Fig 1 shows the distribution of biologically effective ultra-violet radiation throughout the four seasons of the year and at various times of the day. This chart leads to the conclusion that during winter and spring months there must be some other source of vitamin D supply to take the place of that not available from natural sources, and especially where high production methods are employed and the chicks are raised entirely indoors.

Vitamin D can now be supplied safely and conveniently through the medium of modern sources of artificial sunlight. These sources and the accompanying equipments that are now available for the production and efficient use of artificial sunlight have been discussed in papers presented by B. P. Hess[3] and H. J. Chanon[4].

Tests which have been conducted by universities and other authorities in the field have proved that the use of ultra-violet radiation from artificial sources will do the following:

1. Increase materially the number of eggs laid
2. Increase the size and weight of the eggs
3. Increase the vitamin D content of the eggs
4. Decrease the breakage from thin shells
5. Increase the percentage of fertile eggs
6. Eliminate loss of chicks from rickets
7. Increase the rate of growth of small chicks
8. Produce larger and stronger pullets
9. Eliminate the necessity and inconvenience of feeding cod-liver oil.

Typical Tests. Due to space limitations, quantitative data can be presented in this paper on only three of the above items—greater egg production, greater egg fertility, and faster growth of chicks. A bulletin containing more complete test data may be obtained from the author.

The effectiveness of artificial ultra-violet radiation in increasing egg production is evidenced by a typical test conducted at the Case and Elling Farm, Concordia, Missouri. The curves in Fig 2 show the greater production of the irradiated group. Of particular significance is the

[1]Abstract of paper presented at a session of the Rural Electric Division of the American Society of Agricultural Engineers during the 26th annual meeting of the Society held at Ohio State University, Columbus, in June 1932.

[2]Illuminating engineer, Nela Park Engineering Dept., General Electric Company. Mem. A.S.A.E.

[3]"Sources of Ultra-Violet Radiation," by B. P. Hess. A.S.A.E. 26th annual meeting paper (1932).

[4]"Equipment for the New Ultra-Violet Sources," by H. J. Chanon. A.S.A.E. 26th annual meeting paper (1932).

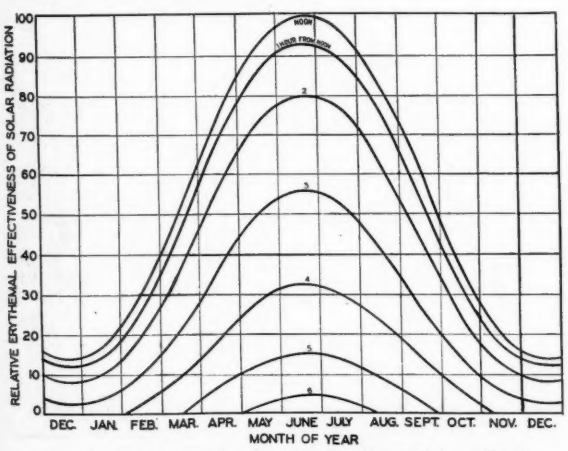


Fig 1. The amount of natural ultra-violet radiant energy varies greatly depending upon the time of day and the season of the year

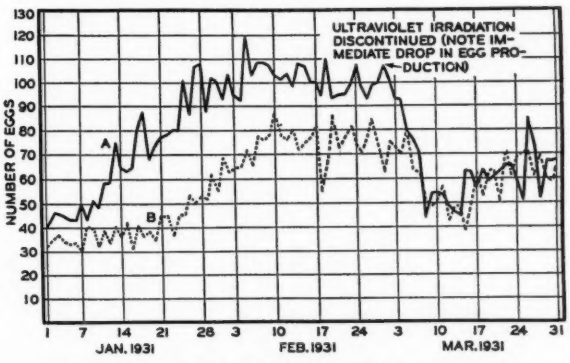


Fig 2. Record of egg production of two groups of a flock. Group A with daily irradiation from Type S-1 Mazda sunlight lamps, and Group B with no irradiation

Table I. Effect of Irradiation on Hatchability and Fertility of Eggs

Pen No.	Treatment	Month	No. eggs incubated	No. eggs fertile	Per cent fertility	No. chicks hatched	Total eggs hatched	Per cent fertile eggs hatched
1	Irradiated	Feb	168	157	93	103	61	66
		Mar	149	141	94	91	61	64
		Apr	207	203	98	142	68	70
		May	190	184	96	126	66	68
2	Non-irradiated	Feb	69	62	90	22	31	35
		Mar	43	30	70	6	14	20
		Apr	50	36	72	0	0	0
		May	35	24	70	0	0	0

immediate drop in production when the irradiation was discontinued. Besides the increase in egg production, the irradiated flock after, as well as during, the test had a better physical appearance than the control flock; combs were more vivid, the birds were more active, and they gave the impression that they were much better developed.

The University of Wisconsin has conducted a test for the purpose of studying the effect of ultra-violet radiation on the hatchability and fertility of eggs. Table I presents the results of this test. Both hatchability and fertility were markedly increased by the irradiation.

The University of Nebraska has conducted a test in which the growth of chicks irradiated 20 min daily with a Type S-1 Mazda sunlight lamp was compared with the growth of chicks receiving sunlight through window glass. It will be noted in Table II that the irradiated chicks gained weight much more rapidly. Of the 35 chicks in each lot, none under the sunlamp developed rickets, and none died. There were 26 cases of rickets in the other group and five deaths.

Typical Installations. The accompanying photographs show typical installations of Type S-1 Mazda sunlight lamps in a poultry house, Fig 3, and 60-w Mazda CX lamps in a battery brooder, Fig 4. Only the last application requires further comment. The small size and simplicity of operation of the 60-w Mazda CX lamp make it adaptable to the confined space of a brooder. Here too, it is necessary to supply heat, and the CX lamp, either burning continuously or on a thermostat, may serve the dual purpose of supplying heat and ultra-violet radiation. A glow lamp may also be used in this application; its first cost is higher, but it need not be burned as long, and its low light output in the visible region is regarded by some authorities as a deterrent to cannibalism.

Table II. Effect of Irradiation on Growth of Chicks

	Weight of chicks under sunlight lamps (gm)	Weight of chicks under sunlight through glass (gm)
2 weeks	130	115
4 weeks	225	185
6 weeks	370	260
8 weeks	515	325

In conclusion, it might be pointed out that a great deal of experimental work is yet to be done. The value of artificial sunlight has been thoroughly established, but the minimum beneficial dosages have not yet been determined. Experiments with this objective are urgently needed.

Engineering Advice

I believe we shall see the time when the progressive farmer,—and there will be no room for any other kind,—will consider money spent for engineering advice to be well invested. Our agricultural institutions must always be responsible for training young men for this important field of work, as well as for a large part of the research directed toward developing new engineering facts applicable to agriculture. And for the present, at least, these institutions must assume practically the entire burden of instructing the farmer in respect to the engineering aspects of his operations.—S. H. McCrory.

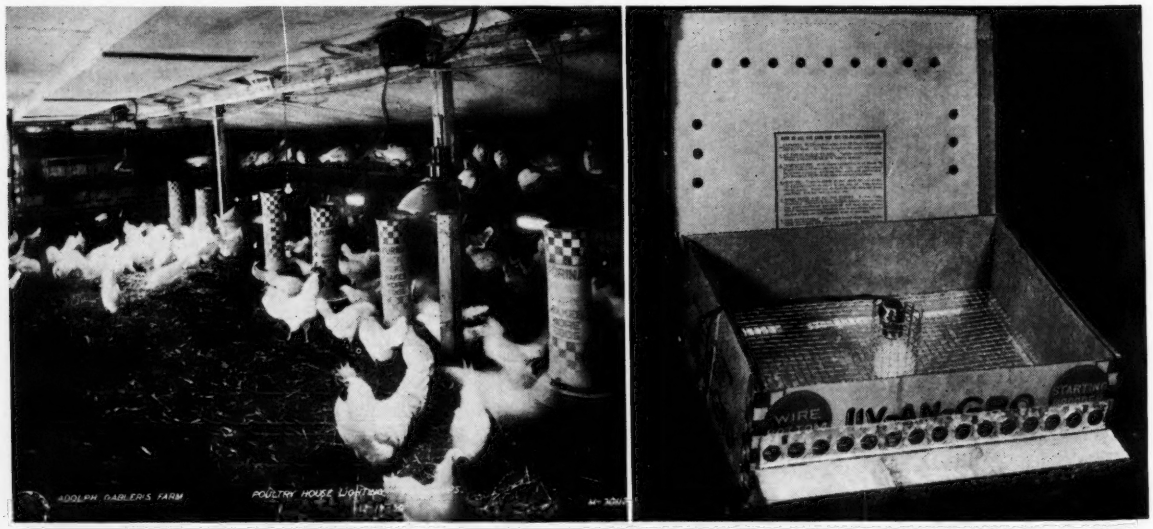


Fig 3. (left) Type S-1 Mazda sunlight lamps should be mounted about 5 ft above the floor and operated ½ and 1 h a day, with one lamp for each 100 to 150 hens. Fig 4 (right) With this type of battery brooder the 60-w Mazda CX lamp provides ultra-violet radiation and most of the heat required

A Comparison of Methods of Mechanical Analysis of Soils[1]

By A. Carnes[2] and H. D. Sexton[3]

SOIL physicists have long considered that a mechanical analysis is a necessary part of any complete soil description. Especially is this description essential when one is endeavoring to explain the reaction of different soils to various physical forces. The work of Briggs and McLane[4], Keen[5], and others has shown that the physical behavior of the soil depends largely upon the smaller particles present. Nichols[6] has shown that friction, shear, cohesion, and adhesion depend largely on the colloidal or clay content of the soil.

The purpose of this study was to find a method of physical analysis that could be used in place of the laborious, tedious, and time-consuming pipette method for the great number of physical analyses needed in soil dynamics and erosion studies.

The U.S.D.A. Bureau of Chemistry and Soils pipette method[7], the Bouyoucos hydrometer method[8], and a modification of the Schone elutriation method[9] of mechanical analysis of soils were investigated. Particular attention was paid to such factors as time requirements, laboratory technique necessary, laboriousness, and accuracy.

The pipette method used was that recommended by the U.S.D.A. Bureau of Chemistry and Soils. This method, though quite accurate when careful attention is paid to technique, is laborious and consumes too much time for each analysis. The same was found to be true for the Robinson method[10].

The elutriator used in this study was of the Noebel four-compartment type. Careful attention to laboratory technique is required to operate an elutriator of this type. To obtain a complete and accurate analysis, the velocity of the water throughout the elutriator must be accurately controlled; this is a rather difficult task. The filtering and weighing of separates consume considerable time and is rather laborious. This method though fairly accurate is not well adapted to soil dynamics work where a great number of analyses are required, except for the study of flocculation as pointed out by Baver[11].

The Bouyoucos hydrometer method[8] used in this study does not require as much time as the pipette and elutriation methods and the technique is simple.

The soils used in this study varied from sandy loam to clay. A physical analysis[12] of each soil was made by using the three methods discussed above. A comparison of results of these tests are shown in Table I.

The results in Table I show that these methods check fairly closely. Any one of the three methods is sufficiently accurate to use for mechanical analyses in soil dynamics or erosion work. In the pipette method the error is accumulative, and the total error occurs in the silt fraction as this is determined by difference. The hydrometer method appears to determine the total clay fraction accurately, but it may not be very accurate in determining the finer clay and colloid fraction. As pointed out by Bouyoucos, if a greater part of the silt fraction in a soil is very fine, the hydrometer will include it in its so-called colloid determination. If the silt consists almost entirely of the coarser sizes, the hydrometer method does not include it in the colloidal determination, and the percentage of colloid will correspond very closely to the percentage as determined by the pipette method. In the table where the hydrometer method differs from the pipette method in the silt fraction, there is a corresponding difference in the colloid fraction which bears out Bouyoucos' findings. This is doubtless due to a high percentage of fine silt in these soils.

It has been shown by Muntz[13] that the heat of wetting increased with the fineness of the soil particles. Likewise Bouyoucos states that the fine silt affects the heat of wetting of a soil. The results obtained by the hydrometer method indicate that very fine silt affects the physical properties of the soil, that is, its ability to affect the specific gravity of a suspension.

The result of the study is summarized as follows:

1. The pipette methods of analysis of soils investigated were found to consume too much time where a great number of analyses were to be made. The same was true with the elutriation method.

2. The Bouyoucos hydrometer method was found to be rapid and sufficiently accurate for work in soil dynamics and erosion studies.

[1]Contribution from Agricultural Engineering Department, Alabama Agricultural Experiment Station, released, by the permission of the Director, for first publication in AGRICULTURAL ENGINEERING.

[2]Assistant professor of agricultural engineering, Alabama Polytechnic Institute, Auburn, Alabama. Assoc. Mem. A.S.A.E.

[3]Research fellow in agricultural engineering, Alabama Polytechnic Institute.

[4]Briggs, L. J. and McLane, J. W. "The Moisture Equivalent of Soils," U. S. Department of Agriculture Bureau of Chemistry and Soils, Bulletin No. 45.

[5]Keen, B. A. "Relation Between the Clay Content and Certain Physical Properties of a Soil." Journal of Agricultural Science, Vol. 11, 1921.

[6]Nichols, M. L. "The Dynamic Properties of Soils, I" Journal of the American Society of Agricultural Engineers, July 1931.

[7]Technical Bulletin No. 170. "Pipette Method of Mechanical Analyses of Soils Based on the Improved Dispersion Procedure." U. S. Department of Agriculture, January, 1930.

[8]Bouyoucos, G. J. "Hydrometer Method for Studying Soils." Soil Science, Volume 25, pp. 365-369, 1928.

[9]E. Schone. "Ueber Schlammanalyses" Bul. Soc. Imp. d. Nat. Moscow, 1867, 40, p. 524.

[10]Robinson, G. W. "A New Method for the Mechanical Analyses of Soils and other Dispersions." Journal of Agricultural Science, Vol. 12, 1922.

[11]Baver, L. D. and Rhodes, H. F. "Aggregate Analyses as an Aid in the Study of Soil Structure Relationships." Journal of the American Society of Agronomy, Vol. 24, No. 11, November 1932.

[12]The pipette analyses were made by F. L. Davis, Agronomy and Soils Department, Alabama Agricultural Experiment Station.

[13]Muntz, A. and Gaudechon, H. "Les degagements de Chaleur qui se produisent au Contact de la terra seche et de l'eau." Ann. Sci. Agron. (3e Ser) 1909, 4 (II), pp. 393-443.

Table I. A Comparison of Physical Analyses by Different Methods

	Pipette Method			Hydrometer Method			Elutriator Method	
Soil	Total sands, per cent	Silt, per cent	Colloid, per cent	Total sands per cent	Silt, per cent	Clay and colloid, per cent	Total sand and coarse silt, per cent	Fine silt clay and colloid, per cent
819 B*	55.90	15.50	28.60	56.60	12.30	31.12	58.97	41.03
813 B	58.80	10.90	30.30	56.66	12.18	31.16	60.42	39.58
815 B	47.50	18.10	34.40	47.72	16.28	36.00	49.50	50.50
809 A*	66.20	19.20	14.60	62.40	21.88	15.72	66.71	33.29
807 A	84.20	9.60	6.20	82.60	8.44	8.96	86.82	13.18

*A horizon and B horizon of the soil.

Certain Errors of Temperature Measurement[1]

By L. M. K. Boelter[2]

THE PURPOSE of this paper is not to cover completely the field of temperature measurements, which is treated adequately in many texts on the subject. The paper will be limited to the measurement of ordinary temperatures by means of mercury thermometers, long-distance indicating thermometers, resistance thermometers, and thermocouples. Further, only certain phases of the use of indicating instruments will be discussed.

The accuracy of the measurement of any variable depends upon the following four factors[3]:

1. Method of application of the instrument
2. Accuracy of the instrument
3. Characteristics of the quantity being measured
4. Accuracy of the observer.

The considerations following will deal primarily with items 1 and 3 above.

The temperatures of gases, vapors, liquids, and solids (in different forms) are required in the solution of many technical problems. These temperatures may be independent of time or vary periodically with time. Also transient phenomena must often be investigated. It is not always advisable to insert the temperature measuring device into the fluid, for example, because of (1) the danger of breakage of a glass thermometer placed in a high-pressure line, (2) corrosion of the thermocouple junction, or (3) the electrical conductivity of the fluid.

THERMOMETER WELLS

The measurement of a fluid temperature by means of a temperature-measuring device placed in a well introduces appreciable errors unless the well is carefully designed[4]. Referring to Fig 1, if the temperature of the fluid exceeds that of the surroundings and the containing wall, heat will be conducted through the film surrounding the well (arrows A, A), along the wall of the well (arrows B, B), and to the wall of the container (arrows C, C).

A temperature potential is required to cause heat flow into the well (arrows A, A). From the theory of conduction (radiation neglected) of heat along a finite rod, the temperature distribution along the well may be expressed as a function of the hyperbolic cosine of the distance. The difference in temperature (t_e) between the fluid and the well near the point at which the thermometer is immersed, will represent the approximate error due to the heat conduction from the well. This result may be expressed algebraically as

$$t_e = t_w \frac{1}{\cosh mL} \qquad [1]$$

where t_e = temperature difference between the end of the well and the fluid in degrees Fahrenheit. (This is the error occasioned by the well.)

t_w = temperature difference between the pipe wall (in which the well is inserted) and the fluid

$$m = \sqrt{\frac{f\,2\,\pi\,r}{k\,A}} \quad (ft^{-1})$$

f = film conductance from the side walls of the well to the fluid in Btu per sq ft per hr per deg F. (The film conductance at the end of the well is considered zero in Equation 1.)

r = outside radius of well in feet

k = thermal conductivity of the well in Btu per sq ft per hr per (deg F per ft)

A = cross-sectional area of wall of the well in square feet

L = length of well in feet.

If the wall of the well is thin compared to the diameter, the area (A) may be written ($2\,\pi\,r\,\delta\,r$), where ($\delta\,r$) is the well thickness. Then the factor m becomes

$$m = \sqrt{\frac{f\,2\,\pi\,r}{k\,2\,\pi\,r\,\delta\,r}} = \sqrt{\frac{f}{k\,\delta\,r}}$$

With this substitution Equation 1 may be written, after subtracting unity from both sides and placing under common numerators,

$$\frac{t_e}{t_w - t_e} = \frac{1}{\cosh L\sqrt{\frac{f}{k\,\delta\,r}} - 1} \qquad [1a]$$

This equation represents the error as a fraction of the difference between the thermometer reading and the pipe wall temperature, and has been plotted on Graph No 1. The use of the equation and the curves will be illustrated by the following example:

The length, L, of a thin-walled steel thermometer well protruding into an oil line is 0.2 ft. The wall thickness ($\delta\,r$) is 0.010 ft. By means of a thermocouple the pipe wall temperature is found to be 100 deg (Fahrenheit) when the thermometer indicates that the mercury bath at the bottom of the well is at 200 deg. If the computed value of the film conductance for the outside of the well is 50 Btu per sq ft per hr per deg F, what is the error in the thermometer reading?

The thermal conductivity of this well is taken as 25 Btu per sq ft per hr per (deg F per ft).

t_w = temperature of wall of pipe minus temperature of fluid

= 100 deg minus temperature of fluid

t_e = temperature of end of well minus temperature of fluid

= 200 deg minus temperature of fluid

$(t_w - t_e) = -100$ deg

$$\frac{t_e}{t_w - t_e} = \frac{t_e}{-100} = \frac{1}{\cosh 0.2\sqrt{\frac{50}{25 \times 0.010}} - 1} =$$

$$\frac{1}{7.520} = 0.134$$

$t_e = -13.4$ deg = error in thermometer reading. The fluid temperature is $200 + 13.4 = 213.4$ deg.

Or, using Graph No 1, from the film conductance of 50 Btu per sq ft per hr per deg F (abscissa) follow vertically upward to the oblique line indicated as $\delta\,r = 0.010$ for the iron wall, and horizontally to the ordinate scale which gives the value of m (logarithmic scale). The product mL is given by subtracting the distance between 0.2 and

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[1]Paper presented at a joint session of the Rural Electric Division and the Power and Machinery Division at the 26th annual meeting of the American Society of Agricultural Engineers at Ohio State University, Columbus, June 1932.

[2]Associate professor of mechanical engineering, University of California.

[3]ASME Test Code, Instruments and Apparatus, Part I, General Considerations.

[4]Grober, Die Warmeubertragung, page 20.

1.0, since $L = 0.2$ ft and the logarithm of 0.2 is minus. (The same result would be obtained by regarding 0.2 as 1/5 and subtracting the distance between 1.0 and 5.0). Passing horizontally from the product mL to curve $t_e \div (t_w - t_e)$ and vertically downward, the value $t_e \div (t_w - t_e) = 0.13$ is read.

Again $t_e = -100 \times 0.13 = -13$ deg

An analysis of Equation 1a yields the conclusion that the error due to conduction from the well may be reduced by the following methods:

1. The film conductance (f) must be as large as possible. This may be attained by making the outside diameter small.

2. For a given length and thickness, the value of the thermal conductivity of the well material (k) must be as small as possible, assuming no heat lost through the stem of the thermometer.

3. The wall of the well should be as thin as possible.

4. The well should be long.

5. External fins may prove advantageous for fluids of low film conductance, i.e., superheated vapors and gases[3].

6. The value of t_w (temperature of the pipe wall minus the fluid temperature) should be small. This can be attained by insulating the pipe wall where the thermometer well is attached, so that the wall approximates the fluid temperature.

The assumptions made in the above example were:

1. The heat transferred through the bottom of the well was considered negligible compared to that transferred through the outer cylindrical walls of the well.

2. The temperatures of the well, mercury, air, and thermometer were assumed to be those which obtain after thermal equilibrium is reached.

3. The temperature of the mercury in the well was considered to be uniform and at the same temperature as the end section of the well, thus neglecting the fact that the inside well wall in contact with the mercury exists at a practically uniform temperature.

4. The heat transferred from the cylinder walls of the well to the mercury, thence to the air directly or through the thermometer stem, was neglected.

5. The heat transferred from the inside cylindrical walls of the well to the air surrounding the thermometer was neglected.

6. The temperature of the well at the pipe wall was assumed to be that of the wall.

7. The thermometer was assumed to be calibrated for the depth of immersion and air temperature conditions existing in this sample computation.

8. The film conductance was assumed constant along the well.

9. The thickness of the well was small compared to the diameter.

10. Either the fluid was athermanous, or radiation was neglected. The radiation inside the well was not considered.

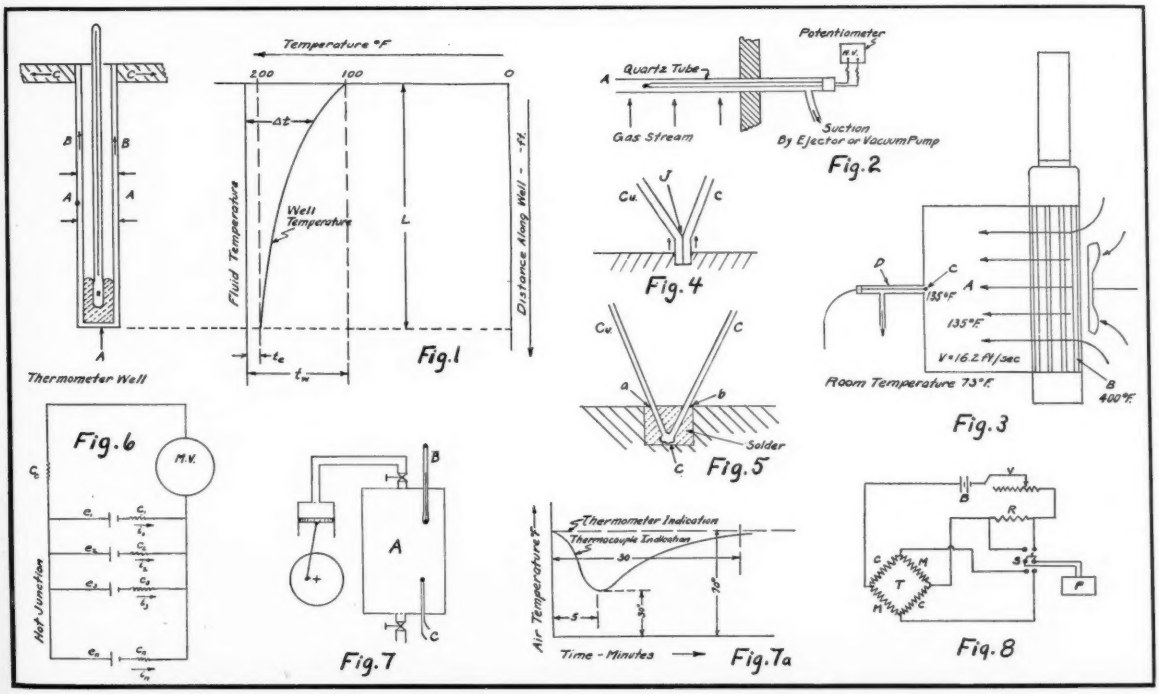
11. The effect of the heat generated at the well by fluid friction was assumed to be included in the film conductance f.

It should be noted that experimental data checking the applicability of Equation 1 or 1a is not available. Further errors of a similar nature, for shielded thermometers, are due to the conduction of heat, from the thermometer bulb, by the metal shield.

CONVECTION THERMOCOUPLE

The measurement of the temperature of a liquid or a gas is subject to the radiation error of the heat-sensitive element of the temperature measuring device. Normally the error is negligible for practically athermanous fluids, or when liquid temperatures are under consideration, because the container wall temperature approaches the fluid temperature. The latter fact is true because the thermal conductance between the liquid and the containing vessel is fairly high. In the case of gases this is not always true. For instance, the gas in a boiler tube may be at a temperature over 1000 deg F while the tube surface temperature is but little higher than that of the fluid on the other side.

The error may be explained by recalling that all of the heat radiated from the couple (or its sheath) and that conducted away along the couple must be supplied to the



couple by convection (free or forced). This implies that the heat must be forced through the thermal resistance of the stagnant film around the couple by a temperature potential equal to the error of the thermocouple reading. Writing this principle in the form of an equation, neglecting the heat conducted away along the couple,

$$\frac{q}{A} = f\ (t_G - t_c) = 1723\ F_A\ F_e \left[\left(\frac{T_c}{1000}\right)^4 - \left(\frac{T_W}{1000}\right)^4\right]$$

where q = heat loss from the thermocouple junction, in Btu per hr

f = film conductance from fluid to thermocouple junction in Btu per hour per deg F per sq ft

t_G = temperature of fluid in deg F

A = area of thermocouple in square feet

t_c = temperature of thermocouple in deg F

F_A = configuration factor depending upon the shape of the bodies between which heat is exchanged[5]

F_e = factor depending on the emissivities of the two bodies[5]. For one body completely surrounded by another and the ratio of the area of the inner body to the area of the outer body small, this factor is approximately the emissivity of the inner body.

T_c = temperature of thermocouple in deg F abs

T_W = temperature of wall surrounding thermocouple in deg F abs.

Following is an example illustrating the error:

A thermocouple encased in a ½-in diameter tube is used to measure the temperature of flue gas in a 24-in flue. The temperature of the flue is 450 deg F, and the temperature at which the couple exists is 565 deg F. The thermocouple is assumed to read accurately the temperature of the enclosing tube.

The velocity of the flue gas is 30 ft per sec, and its specific weight is 0.0416 lb per cu ft. From these data the magnitude of the error which may be expected is computed. The film conductance, f, is taken as 14 Btu per ft per hr per deg F[6].

$T_c = 565 + 460 = 1025$ deg F abs

$T_W = 450 + 460 = 910$ deg F abs

$t_c = 565$ deg F

For black bodies F_e is unity and the thermocouple and flue surface will be considered such. The thermocouple is almost inclosed by the flue (except at the ends) so that F_A may be taken as unity[7]. Then

$$14\ (t_G - t_c) = 1723\left[\left(\frac{1025}{1000}\right)^4 - \left(\frac{910}{1000}\right)^4\right]$$

$$= 1723\ (1.104 - .685)$$

$(t_G - t_c) = 1723 \times (0.419 \div 14) = 51$ deg F, an error of 8.4 per cent.

Comparing the temperatures,

Gas temperature, $t_G = 616$ deg F

Thermocouple temperature, $t_c = 565$ deg F

Wall temperature, $t_W = 450$ deg F

If the thermocouple were radiating to a boiler tube at a lower temperature, the error would be greater. At higher gas temperatures, the error would have been greater since the difference in the fourth power of the absolute temperatures is larger.

Several methods of reducing this error have been proposed, the most promising of which is termed a convection (or high-velocity) thermocouple[8]. It may be shown[9] that, if a thermocouple is surrounded by a tube, the emissivity of which is unity, and the thermal conductivity of which is great, the heat loss from the couple will be reduced one-half. A second shield will reduce the heat radiated to one-third compared to that radiated from the thermocouple, and, by extension, "n" shields will reduce the heat transferred to 1 ÷ (n + 1) of its original value. If gas temperature conditions permit, a shield which is a good reflector (and therefore a poor emitter) will still further reduce the radiation losses.

Another method of reducing the error ($t_G - t_c$) is to increase the thermal conductance of the film surrounding the thermocouple. The conductance is a function of both the diameter of the thermocouple and the fluid velocity, varying approximately as the square root of (velocity ÷ diameter) for air. In cases where the gas flow past the thermocouple (located in a properly designed shield) is not sufficiently great (less than 20 ft per sec), and arrangement shown in Fig 2 is suggested. The thermocouple should "see" a minimum portion of the cool or hot surfaces and a more elaborate shield design would place a double reversed path at the entrance (A).

Certain combinations of variables may make the application of a radiation shield practically useless. The following example is cited:

In the test of a gas heater the temperature of air (arrows A) (Fig 3) forced over heated vertical tubes (B) was measured by means of the previously described high velocity thermocouple (C).

When in the shielding tube (D) the thermocouple indicated a temperature only 0.4 deg F lower than when placed directly in the air stream. When the thermocouple was directly in the air stream the following heat transfer occurred:

1. Heat was transferred by radiation from the tubes (B) at 400 deg F to the thermocouple (C) at 135 deg F, or to the galvanized iron hood and by reflection to the thermocouple.

2. The thermocouple at 135 deg F lost heat by radiation to the room walls at 73 deg F.

3. Heat was carried away by the air with a film conductance of about 40 Btu per sq ft per hr per deg F. (The wire diameter was small and the air velocity = 16.2 ft per sec.)

Items 1 and 2 are small compared to the film conductance. Hence $t_G - t_c$ = (Item 1 — Item 2) ÷ 40 is small, smaller than either the effect of Item 1 or Item 2 alone.

In order to obtain the average temperature of a fluid flowing in a closed conduit, it may be necessary to provide a stirrer upstream from the temperature measuring device. This caution applies particularly to viscous flow, in which, due to the laminar distribution of velocity, large temperature gradients may exist across the stream.

METAL SURFACE TEMPERATURES

It is often necessary to measure the surface temperature of a metal. The mercury thermometer, because of its size, is ill-adapted for this purpose; thermo-couples, on the contrary, are found very satisfactory. In the following paragraphs methods of attaching the thermo-couple to the metal will be discussed. (See Mech. Eng., Aug. 1932, p. 553. Article by H. P. Bailey, published since this paper was presented.) Various methods are suggested[10]:

1. Touched to surface
2. Peened into position
3. Junction forced into a narrow slot

[5] H. C. Hottel, "Radiant Heat Transmission," Mechanical Engineering, volume 52, July 1930.

[6] Assume flue gas has the same film conductance as air and refer to E. L. Chapell and W. H. McAdams, "Heat Transfer for Forced Flow of Air at Right Angles to Cylinders," ASME Transactions, volume 48 (1926) page 1220. See also Walker, Lewis, and McAdams, "Principles of Chemical Engineering," page 151, equation 37.

[7] Grober, Die Warmeubertragung, page 131.

[8] "Measurement of the Temperature of a Flowing Gas," Haslam and Chappell, Bulletin No. 124, Massachusetts Institute of Technology, May 1925.

[9] Grober, Die Warmeubertragung, page 129.

[10] Other methods are discussed in Bulletin No. 70, University of Wisconsin, "Studies in Heat Transmission," Colburn and Hougen, pages 68-70.

4. Junction mounted in a small copper plug which in turn is driven into a small hole
5. Soldered or brazed to surface
6. Held in position by low-melting point alloy (Wood's metal)
7. Electroplated
8. Placed into a small well.

On Graph No 2 are shown the results of measurements of the surface temperature of an iron pipe (slightly rusty) using No 24 copper-constantan, brazed-junction thermocouples attached in the following manner:

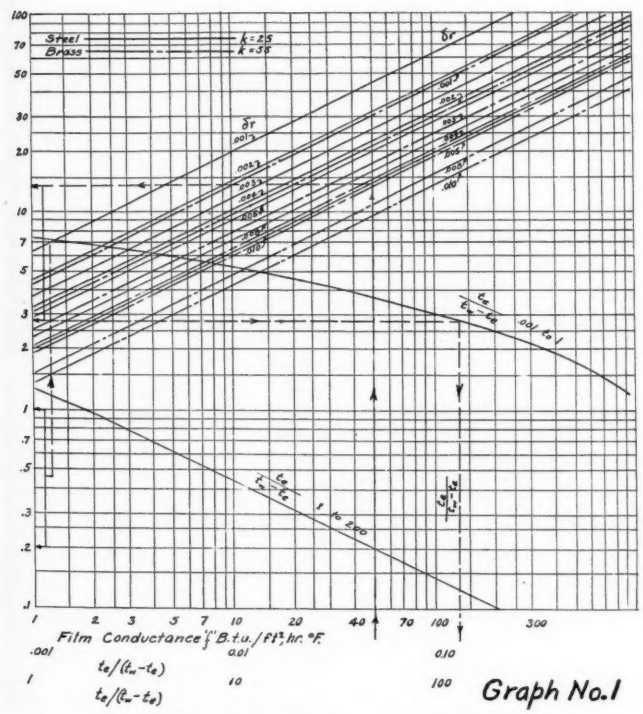
1. Peened into hole in rust-covered surface
2. Peened into the surface at a point which had been "brazed over"
3. Brazed to surface
4. Brazed to surface — thermocouple wires wrapped around the pipe once
5. Placed into a small oil-filled hole in a rust-covered surface
6. Peened into hole in rust-covered surface.

It will be noted that the temperature determination by thermocouples which were peened into the surface did not agree. By peening the thermocouples into position more tightly, the results were in agreement within the precision of the potentiometer (± 0.02 mv) with those obtained by brazing the thermocouple into position.

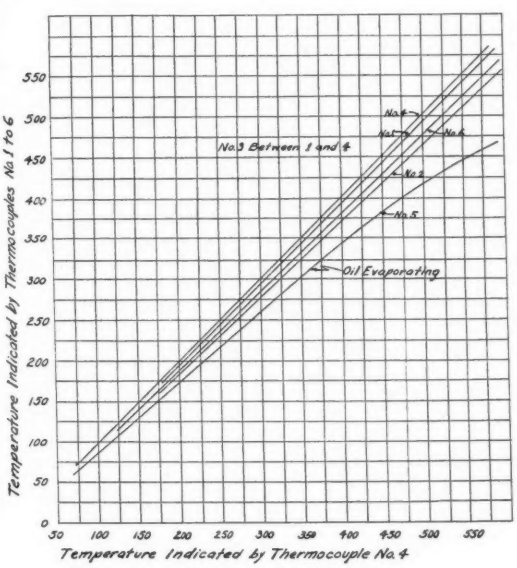
A further point with respect to the attachment of the thermocouple is the fact that heat will be carried away from the junction by conduction along the thermocouple wires, if the surroundings are at a temperature less than that of the surface under consideration. This effect will reduce the temperature of the junction below that of the surface; the error will depend upon the thermal resistance between the surface and the junction. For this reason the thermocouple immersed in the oil well (Thermocouple No 5, Graph No 2) indicates a lower temperature than the others. The heat conducted away from the junction along the wire may be reduced by decreasing the thermocouple wire size. Further, if a short length of the wire is placed in thermal contact with the surface (existing at the same temperature as the junction), but insulated electrically therefrom, the heat loss from the junction will be reduced. Thermocouple No 4 reads higher than No 3 because the conduction error has been reduced. The error is small in this case but would be larger for a larger thermal resistance between the thermocouple and the pipe. Often a short length of wire is cemented into a groove with litharge in order to fulfill the conditions stated above.

The character of the surface around the thermocouple junction will be changed by soldering or brazing. In the case of a rusty iron pipe the emissivity of the surface is reduced considerably because the solder or brass presents a surface which is a fair reflector. This error may be reduced by keeping down the area of the weld. Then if the thermal conductivities of the weld and the surface are identical, no appreciable error will result within the ordinary temperature range. No decrease in temperature (within the precision of the potentiometer, ± 0.02 mv) of the surface was observed by lamp blacking the brazed area surrounding the junction, which indicated that the radiation effect noted above is negligible.

The temperature of the surface of the pipe was also observed by means of a touch thermocouple. Much more consistent and slightly higher results were obtained on the brazed surface compared with the slightly rusty pipe surface. The variation in readings, depending upon the method of application, was about ± 5 deg F for a surface temperature of 166 deg F.



Graph No 1. Error in temperature reading caused by conduction along the wall of thin-walled thermometer wells
$t_e \div t_w = 1 \div \cosh m L$ t_e = thermometer (fluid) temperature
$t_e \div (t_w - t_e) = 1 \div [\cosh (m L) - 1]$
t_w = wall (fluid) temperature $m = \sqrt{f \div k \delta r}$, ft^{-1}
f = film conductance to well, Btu per hr per sq ft per deg F
δr = wall thickness, ft
k = thermal conductivity of well, Btu per hr per sq ft (per deg F per ft)



Graph No 2. Comparison of methods of attaching thermocouples to the surface of an iron pipe. No 1. Peened into hole in rust-covered surface. No 2. Peened into hole in brazed-over surface. No 3. Brazed to surface. No 4. Brazed to surface (thermocouple wire wrapped around pipe once). No 5. In an oil-filled hole in rust-covered surface. No 6. Peened into hole in rust-covered surface. (All thermocouple brazed-junction, copper-stantan No 24 wire.)

The rusty surface temperature was found to be 154 deg F by this method, that is, 12 deg F too low.

Care should be taken that the junction of the thermocouple wires (the line along which the wires first contact) coincides with that of the surface of which the temperature is desired. If this contact is outside of the surface, the resulting indication will be low (but above that of the surrounding fluid). Good thermal conduction from the surface to the junction (J) along the wires, shown by an arrow in Fig 4, will minimize this error. If the junction is below the surface and soldered into position, as shown diagrammatically in Fig 5, the electromotive force generated at "a" (e_a) is between the copper and the solder at temperature (t_a) while e_b at "b" is between constantan and solder at temperature (t_b). If $t_a = t_b = t_c$, then $e_a - e_b = e_{cwc}$, the voltage which would be generated if the copper-constantan contact were at the surface.

A thermo-couple circuit may be considered as the following equivalent circuit (Fig 6), consisting of distributed thermo-cells of voltage (e) with a series path of conductance (c). If the hot junction does not exist at a uniform temperature, the voltage along the junction will vary. By the application of Kirchhoff's Laws it may be shown that

$$E = \frac{e_1 c_1 + e_2 c_2 + \ldots e_n c_n}{c_1 + c_2 \ldots c_n}$$

$$= e_1 + \frac{\frac{c_2}{c_1}(e_2 - e_1) \ldots \frac{c_n}{c_1}(e_n - e_1)}{1 + \frac{c_2}{c_1} + \ldots \frac{c_n}{c_1}}$$

It may be seen that if $e_1 + e_2 = \ldots e_n$, the circuit voltage (E) will be the voltage at the "first" junction of the dissimilar metals. Also that if $c_1 = \infty$ (a good junction), $E = e_1$. If any other path presents a large conductivity, say $c_n = \infty$, then $c_n \div c_1$ approaches unity and the circuit voltage will be

$$E = e_1 + \frac{e_n - e_1}{2}$$

for $c_2 \ldots c_n - 1$ negligible. These equations for the equivalent circuit show the necessity of keeping the junction small and at a uniform temperature. N. P. Bailey in the November 1931 "Mechanical Engineering," in an article, entitled "Response of Thermocouples," illustrates the effect of abnormal temperature gradients at thermocouple junctions.

While[11] an electro-deposited junction distributed over the surface of which the temperature is desired (say nickel plating on a copper pipe) apparently presents some advantages, a study of the equivalent circuit will yield the conclusion that, since the conductivity at the point where the nickel wire leaves the copper is very high, this couple will read the approximate temperature at this point. This method does not present advantages even though a broad interface exists between the two metals.

A number of thermoelectric elements may be connected in parallel in order that the average temperature of a body be obtained. The resulting circuit may be analyzed by means of the equations derived above and is subject to the errors cited. The method has been used successfully by Colburn and Hougen ("Studies in Heat Transmission," p. 65), but it is recommended that the accuracy of the circuit be established by an independent determination of the temperature at each point.

Extreme accuracy (± 0.002 deg F) demands great care in the handling of the thermocouple wire. A sharp kink or a strain will introduce another junction, the electromotive force of which will add or subtract from that existing between the hot and the cold junction. Equivalent junctions exist along the wires due to non-homogeneity. The longer the length of wires existing at a given temperature, the more nearly these effects will cancel. If wires of impure metals are used, it is advisable to maintain a low and definite temperature gradient along the wire.

Temperature strains will cause thermo-electric cells near the junctions when the wires are heated to a high temperature during construction. For this reason soldering of the junction is recommended if the operating temperatures will permit. It is also not advisable to repair a break in a wire. Deterioration of the junction due to contact with gases or the occlusion of gases by the metals of the couple will introduce errors. (See Roeser—Journal of the Bureau of Standards, Research Paper No 354, Vol 7, September 1931, The Passage of Gas through Walls of Pyrometer Protection Tubes at High Temperatures.)

COLD JUNCTION

An ice cold-junction is satisfactory when ordinary temperatures are being measured. It is important to place the ice (in equilibrium with water) in a corked Dewar flask. Care should be taken to use ice made of distilled water (negligible electrical conductivity), and it is often desirable to use separate containers for each cold junction. Stirring the water and ice mixture will cause the warmer water near the outside surfaces of the flask to move to the center. Cold junctions may be insulated from each other (to avoid parasitic currents) by placing them into small glass tubes and pouring naphthalene around the wires.

Cold junction compensation is often effected by mechanical or electrical means in indicating or recording instruments. It is important in this case to keep the whole compensation circuit at a uniform temperature. A temperature gradient of approximately 100 deg F across the cold junction has resulted in an error of approximately 10 deg F in the temperature reading of the instrument.

MEASURING INSTRUMENTS FOR THERMOCOUPLES

For laboratory work, the potentiometer circuit should be employed to measure the voltage generated in the circuit due to the difference in temperature. Galvanometers or milliammeters indicate the current which is caused to flow in the circuit. This current depends not only upon the voltage but upon the resistance of the circuit. The latter is subject to change due to deterioration of the junction, change of leads, or change in the temperature of the leads. In general, when deflection instruments are used, those of high internal resistance are to be preferred. A discussion on this subject may be found in February 1923 Transactions, A.I.E.E. Journal, pages 356-7, at the end of the article by I. G. Smith, on "Temperature Measurements." Current type instruments are satisfactory and desirable for certain classes of industrial installations.

THERMOCOUPLE CALIBRATION AND METALS

In general, a thermocouple should be calibrated under the conditions of use. Fixed points, melting, transition and boiling points within the range in which the couple is to be used may be employed. A parabola may be drawn through the calibration points. It is often convenient to tabulate the deviations from a straight line rather than the calibration data itself[12].

A suggestion against the use of manufacturer's charts or curves for thermocouples will be made, unless a deviation curve representative of the particular spool of wire used in making the thermocouple is known. For precision work all couples must be calibrated, even if taken from the same spools. However, for most industrial purposes the calibration of one thermocouple per spool is sufficient. The temperature indicated by thermocouples from the same spools may vary as much as 40 deg in 1800 deg F.

The deviation from the standard curve need not be large if the proper precautions are taken. Certain thermocouple wires (chromel-alumel) are difficult to make absolutely uniform. The properties of each quantity of wire made may

[11] Colburn and Hougen, "Studies in Heat Transmission," page 69.

[12] Ostwald-Luther; Physiko-Chemische Messungen; 5th Edition, 1931, pages 704-709.

vary slightly. In such cases, the wire is labeled as class M, N, L, etc., indicating groups in which the deviation from the standard curve is about the same. The precaution to observe when making a thermocouple is the selection of two wires from the same group, thus making the deviation small. (If the deviation of each wire is exactly the same, the thermocouple could be used with a standard curve.) The above classification is determined by matching an unclassed wire with a wire known to have zero deviation (or a known deviation) and calibrating.

Also, manufacturers' charts are above a base temperature, say O deg F, and all data must be oriented with respect to this datum, if the calibration curve is other than a straight line.

The choice of metals for a thermocouple depends upon the conditions of use, particularly temperature. Wires with the higher voltage temperature coefficient (de ÷ dt) are usually used because less sensitive instruments need be employed[13]. Deterioration of the junction may be prevented by placing the hot thermocouple junction into a properly designed tube.

An increase in voltage for a given temperature difference may be obtained by placing a number of thermocouples in series. Great care must be taken to prevent parasitic currents when employing these multiple-junction thermocouples. Parasitic currents are due primarily to short-circuits in the thermocouple circuit, but may also arise due to induction (causing heating at the junction) and by galvanic action.

THERMOMETRIC LAG

Often the temperature being measured varies with time, and if the instrument does not follow this variation quickly, considerable error will result. Citing a series of tests[14] on three types of airplane instruments, the liquid-filled, bimetallic, and resistance thermometers are listed in the order of decreasing lag. The time lag of liquid-filled thermometers (using the bourdon pressure element) exceeds that of the gas-filled or vapor-pressure type.

The lag of mercury thermometers is discussed in the Bulletin 185 of the U. S. Bureau of Standards, volume 8, "Thermometer Lag," by D. R. Harper. It is pointed out that the lag of a falling mercury column will differ from that of a rising column due to the uncertainty of the resisting forces (capillarity and surface tension). A particular example will be taken from the above quoted source. An ordinary mercury thermometer placed in water rising at a rate of 0.03 deg F per minute will require a correction of + 0.002 deg F.

In addition to the lag due to the thermometer, a lag of far greater magnitude may be introduced by the surroundings. This is illustrated by the following example:

The temperature of air in a tank (A) during evacuation was desired (Fig 7). An attempt to make the measurement by means of a mercury-in-glass thermometer (B) falsely indicated that the air temperature did not vary during the process. However, the use of a small diameter thermocouple (C) showed that the air temperature was lowered approximately 40 deg F during the first five minutes (Fig 7a). The error in temperature given by the mercury-in-glass thermometer was due to the radiation from the walls and the poor film conductance of the stagnant air. The poor film conductance also prevented the walls from rapidly dropping in temperature.

MEASUREMENT OF PERIODIC TEMPERATURES

The determination of the temperature of a vapor in an engine or of the cylinder wall of an engine presents interesting problems. Data has been recently presented by Nägel ("Der Wärmeübergang zwichen Dampf & Zylinderwand bei der Gleichstrom—Dampfmaschine") and Eichelberg ("Zeit-Forschungsarbeiten Heft No 300). These concern the periodic temperature variations in Unaflow and Diesel engines, respectively.

Nägel used a resistance element to determine the steam temperature and thermo-couples for the wall-surface temperatures. An oscillograph was used to record the variations.

The thermal resistance between the temperature measuring element and the fluid will introduce not only a reduction in amplitude of the recorded temperature over that of the fluid, but also a phase lag. These errors depend upon many variables but may be reduced by increasing the thermal conductance of the film surrounding the temperature-sensitive element and decreasing the heat capacity of the unit. The temperature-measuring device will follow variations of low frequencies more accurately than high frequencies. The relation for a sinusoidal temperature variation is derived by Bailey[15], assuming an infinite thermal conductivity of the thermo-couple as

$$t = \frac{t_o \sin\left(w\Theta - \tan^{-1}\frac{wc}{f}\right)}{\sqrt{1 + \frac{w^2 c^2}{f^2}}}$$

where t_o = amplitude of the temperature variation of the fluid in degrees Fahrenheit

t = amplitude of the recorded temperature

$w = 2f\pi = 2\pi \times$ frequency of the sinusoidal temperature variation in cycles per second

Θ = time elapsed in seconds

c = heat capacity per unit length of the temperature sensitive element in Btu per deg F per ft

f = film conductance per unit length of the temperature sensitive element in Btu per deg F per sec-ft

This equation shows that the amplitude is reduced to a fraction

$$\frac{1}{\sqrt{1 + \frac{w^2 c^2}{f^2}}}$$

and the phase lag is an angle $\propto = \tan^{-1}(wc \div f)$. It also reveals that, if the temperature variation is not sinusoidal, the error will increase for the higher harmonics of the temperature curve. In the above discussion the transient term was neglected.

EFFECT OF TEMPERATURE GRADIENTS

The first three classes of this group usually consist of a bourdon tube connected by means of a capillary tube to the temperature-sensitive element or bulb. In the fourth, the expansion of a bimetallic spring is transmitted to the indicating mechanism. The four classes will be listed as follows depending upon the actuating force:

1. Expansion of a liquid
2. Vapor pressure
3. Expansion of a gas
4. Bimetallic strip.

Considering Classes 1 to 3, the temperature-sensitive elements are subject to the corrections noted under thermometer wells. The indicating gage, the capillary and the bulb, may exist at widely different temperatures. The expansion of the bourdon tube when subjected to temperatures other than the calibration temperature may be corrected by the use of a bimetallic spring. The fluid expansion within the bourdon tube and the capillary will cause appreciable errors when the different parts of the system

[13] See VdI Band 75, No. 23, June 6, 1931, p. 731, for a discussion of (de/dt) for thermocouples for high temperatures. A. Schulze, "Uber die Verwendung von thermoelementen in hohen Temperaturen."

[14] "Thermometric lag of Aircraft Thermometers, Thermographs and Barographs; Hendrickson, Research Paper No. 22, Bureau of Standards.

[15] Mechanical Engineering, November 1931, page 803, "The Response of Thermocouples."

are subjected to temperature gradients different from those existing during calibration.

In the liquid type (Class 1), a bimetallic spring is provided to counteract the expansion of the liquid in the bourdon tube. No correction is made for the expansion of the liquid in the capillary, but its volume is kept as low as possible compared to the total volume of the system. Similar errors but of lower magnitude will result in the gas-filled type (Class 3).

The effect of temperature gradients on Class 1 and 3 thermometers will be illustrated by an example using a gas-filled type (Class 3). A thermometer of range 50 to 800 degrees (Fahrenheit) and a 100-foot capillary was subjected to a temperature change of 30 deg along the entire length. The following temperature error resulted:

Instrument Reading	Error
600 deg	12 deg
375 deg	7 deg
212 deg	5 deg

A 30 to 212-deg range thermometer with a 50-ft capillary equipped with the same bulb as the thermometer noted above and subjected to the same temperature change along the capillary (from that existing during calibration) caused an error of 18 deg. The difference in the performance of the instruments of different ranges is due to the difference in design, particularly the initial pressure and the sensitivity.

Vapor-pressure (Class 2) thermometers possess the advantage of not being subject to the errors due to temperature gradients along the capillary and bourdon tube provided equilibrium of the system has been attained.

Conditions of operation of Class 2 thermometers may require that the bulb be mounted erect, horizontally, or inverted, and for each bulb installation, the bourdon tube may be mounted above or below the bulb. Further, the bulb may be hotter or colder than the capillary and bourdon tube. Eight cases are listed and discussed in the A.S.M.E. Code on Instruments, Part 3, "Temperature Measurement," Chapter 7, "Pressure-Gage Thermometers." Quoting from Diederichs and Andrae, "Experimental Mechanical Engineering," p. 132, "The net results of a complete analysis would seem to be the following:

"1. When the bulb is hotter than the capillary, which is the usual case, the indicator (bourdon tube) may be installed above or below the bulb, and the bulb may be either in the erect, inclined, horizontal, and vertical position. The only corrections that need be made in these cases are due to the fact that, when the indicator is above the bulb, the vapor pressure supports a column of liquid in the capillary ascending to the indicator which will cause the indicator to read too low, and when the indicator is installed below the bulb, there will be a column of liquid standing in the capillary above the indicator, which will make the latter read too high. It is well to calibrate the instrument with the same relative position of its parts, the error due to these liquid columns will then be zero, if the temperature of the capillary is the same in service as during calibration.

"2. When the bulb is colder than the capillary, it is essential that the bulb be installed in the erect position." If the bulb is not erect the pressure existing in the system will correspond to the temperature at which vaporization occurs, and this will be the temperature of the capillary.

In bimetallic-expansion (straight or helical strips, Class 4) thermometers, the gage cannot be placed at a distance from the bulb. This class possesses a high thermometric lag and must be immersed in accordance with conditions of calibration.

RESISTANCE THERMOMETERS

This type of measuring instrument is described in the literature. The following references are cited: (1) Bulletin No. 124, U. S. Bureau of Standards, volume 6, "Platinum Resistance Thermometry"; (2) "Pyrometry," American Institute of Mining & Metallurgical Engineers, 1920; (3) "Dictionary of Applied Physics," volume I, Glazebrook; and (4) Ostwald-Luther, Physiko-Chemische Messungen, 5th ed., pp. 698-706. It is particularly adapted to the measurement of the temperatures of gases and liquids, but due to the size of the thermo-sensitive element, its application to the determination of localized temperatures is precluded. Wires available commercially for resistance thermometers are platinum, copper, nickel, iron, and tungsten. Of these, nickel and iron possess the highest temperature coefficients, namely, 0.30 to 0.37 per cent per degree (Fahrenheit). Variations of the resistance for a given metal are due to impurities or drawing strains. Platinum and copper wires are obtainable commercially in a good state of purity. Maier[16] states that the ductility, low-annealing temperature, freedom from strain and thermal electromotive forces, and the high commercial purity commend copper for resistance thermometers, even though its coefficient (about 0.24 per cent per degree) is inferior to that of platinum.

Circuits of various forms have been developed for use in connection with the resistance thermometer. The advantages of these circuits relative to lead resistance compensation, sensitivity, etc., are discussed in the references cited. Maier (ibid.) has developed a modified thermometer which is suitable for ordinary laboratory work. The following description is quoted from his paper:

"Four windings are provided in the thermometer itself, all having identical resistances at some definite temperature. Two of the coils are of manganin and two of copper, and they are connected alternately as in a Wheatstone bridge loop. The internal and external circuits are shown in Fig. 8, where the copper and manganin coils of the thermometer (T) are marked C and M, respectively. Current leads are provided between two opposite junctions of the bridge, and the remaining junctions are connected to potential leads. A battery (B) of one or two cells furnishes energy to the bridge through the variable resistance (V) and the standard resistance (R), which may be conveniently 10 or 100 ohms. The double-pole, double-throw switch (S) serves to connect either the terminal potential of the standard resistance, or that from the potential junctions of the thermometer to the instrument (P), which may be either a small portable potentiometer, a millivoltmeter of high resistance, or a galvanometer of variable sensitivity.

"The significance of the transposed bridge arrangement of the thermometer coils will be apparent when it is realized that no matter what the temperature the division of current between the upper and lower loops will be identical if the resistances have been adjusted to the same values at some definite temperature. This temperature is the zero point of the thermometer scale. Using the same wire as that for the first instrument described above, four coils were wound to have a resistance of 258.44 ohms at 77 deg F (25 deg C). The temperature coefficient of each copper coil is then 0.556 ohm per degree at 77 deg F, and this temperature is also the zero point of the temperature scale. Had the copper coils remained the same, and the manganin been adjusted to 233.50 ohms, the zero would have been at 32 deg F (O deg C), and the coefficient still 0.556 ohm per degree at 77 deg F (25 deg C). These figures are derivable from Equations 1 and 2 (cited in the paper).

"The construction of the modified instrument as built in this laboratory was identical with the design of Fig. 1, except that the copper coils were found doubly upon a ¾-in inside diameter, 1/16-in wall, 3 in (long) seamless hard-drawn copper bobbin, and the No. 38 double silk-covered wire manganin coils were wound over them. In connecting the coils, they were arranged so that the currents in them would pass in the opposite sense in each set of similar material, making the instrument non-inductive.

"The method of use of this instrument will be obvious. The current through the thermometer is adjusted to a

[16] C. G. Maier, "Resistance Thermometers for Chemists," Journal of Physical Chemistry, volume XXXIV, pages 2860-8, December 1930.

suitable value by means of the variable resistance V, as, for example, 5 ma. The potential across the standard 10-ohm resistance is then 50 mv—a suitable figure for the type of portable potentiometer generally used for thermels (thermocouples) of base metal. Under these circumstances the electromotive force on the potential leads is 2.5 mv per deg C difference (1.39 mv per deg F) between the zero point of the instrument and the measured temperature. The sensitivity is that of the galvanometer or scale of the potentiometer.

"Comparing these figures with those of equivalent thermels (thermocouples), it is apparent that the resistance thermometer furnishes a potential equivalent to 250 multiple junction of platinum-platinum rhodium, or 62 junctions of base metal. The electrical energy dissipated as heat in the thermometer is approximately 0.1 cal per min (0.0003968 Btu per min). The enormous superiority of the resistance thermometer as compared to thermels (thermocouples) for temperatures near ordinary is thus apparent."

MERCURY THERMOMETERS

The use of mercury-in-glass thermometers is subject to corrections noted above (thermometic lag, well connection, etc.), but in addition care should be exercised to use the thermometer under the exact conditions of calibration. Stem corrections, due to difference in expansion of glass and mercury, are necessary if the thermometer is not used with the same immersion for which it was calibrated. (See Technical Paper No 170 of the U. S. Bureau of Standards, "Pyrometric Practice," page 15, and the A.S.M.E. Inst. Code.) An expression of the stem correction to be applied to a thermometer calibrated for full immersion recommended in Diederichs and Andrae, "Experimental Mechanical Engineering," p 122, is

$$t = t_1 + \frac{D\ (t_1 - t_2)}{11{,}364} \text{ deg F}$$

where t = real temperature of the bulb, in deg F

t_1 = indicated temperature

t_2 = temperature of the stem, indicated by an auxiliary thermometer

D = length of the emergent thread, in deg F.

A 400-deg F thermometer reads 380 deg (t_1), the stem temperature (t_2) is 80 deg, and 300 deg is the length (D) of the emergent thread. The true temperature (t) is

$$t = 380 + \frac{300\ (380 - 80)}{11{,}364} = 388 \text{ deg F}$$

A correction of —0.01 deg per unit pressure (lb per sq in) on the bulb (above that existing during calibration) is suggested in the A.S.M.E. Instrument Code. The true magnitude of the correction must be obtained by calibration.

CONCLUSIONS

But a few of the common corrections and precautions necessary for the correct measurement of temperature have been cited. Difficulties which cause no appreciable errors in engineering work, if accuracy required is ± 0.5 deg F, were discussed, because of the fact that a cumulative error may result due to the omission of a number of corrections. In the thermocouple and resistance thermometer circuits, extreme caution must be observed to prevent stray currents.

Many problems arise in practice for which the temperature must be defined, as the reading of a certain instrument under specified conditions. It is important that the instruments be calibrated as nearly as possible under the conditions of use.

A more detailed account of the measurement of ordinary temperatures will be found in Refrigeration Engineering, volume 10, number 6, "Temperature Measurements," P. Nicholls.

Some Thoughts on an Engineer's Policy for Agriculture[1]

By W. G. Kaiser[2]

THE READJUSTMENTS which we are experiencing, reemphasize the need for developing an engineer's policy for agriculture. And, in a sense, the agriculture engineer has been forced to take a defensive position.

Overproduction frequently is cited as the underlying cause of the depression, and it is claimed that overproduction is the result of the too wide use of labor-saving equipment, resulting in unemployment. In my opinion, however, the present period of depression and stagnation is not the result of one but of a number of factors, one of which is our inability to readjust our habits and modes of living.

We cannot go on increasing production unless consumption can be increased. The amount of food that we can eat is limited. Due to changing habits of living, present consumption per capita is perhaps less than in former years.

It is true that we cannot rely on an increasing population to provide an ever-increasing demand for farm products. We are told that we are rapidly approaching a time when the population of this country will not increase or decrease. It will become stable as in France, England, or in a number of European countries. Too, the foreign demand for our food products is on the decline. High tariffs are encouraging home production of foodstuffs in countries which formerly bought heavily of our farm products.

What applies to food products applies to some extent to textiles. Here, also, changing modes of living have decreed that we wear less rather than more clothing. Someone with a sense of humor has said that in the years gone by two sheep had to work a year to produce enough wool to provide the garments of a woman. Now the same authority says that a single silk worm can do the job on a Sunday afternoon!

If we are to develop along national rather than along international lines, then we must find an outlet for our energies within our own boundaries. There is no lack of work to be done. There is much evidence at hand to show that we are about to see a decentralization of industry.

People moving out from the cities, accustomed as they are to the conveniences common in large centers, will want the same conveniences in their suburban or rural homes. Also, being accustomed to factory methods, they will be receptive to applying these methods to their farming operations even though conducted on a modest scale. When this decentralization will come to pass, time only will tell. Regardless of that, however, I would like to offer the suggestion that we examine the possibilities which may wait us in directing our energies toward the wider utilization of the products of engineering rather than toward increasing production of raw materials of which there apparently already is a too plentiful supply.

Might it not be well under existing conditions to give greater attention to those things which make farm life more attractive as well as more profitable? I mean such things as housing conditions, greater utilization of household conveniences and utilities, better shelters for livestock and the development of machine methods which will be adaptable alike to small and large farm units.

In developing an engineer's policy for agriculture, let's do so as a part of a broad national policy that will take into consideration all the industrial, economic, and social factors which will work together to bring about true progress.

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[1]A contribution to the discussion of "An Engineer's Policy for Agriculture," at the 26th annual meeting of the American Society of Agricultural Engineers held at Ohio State University, Columbus, in June 1932.

[2]Agricultural engineer, Portland Cement Association. Mem. A.S.A.E.

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Engineering-Social Problems

SOCIAL aspects of agricultural engineering are to be emphasized in the general sessions of the annual meeting of the American Society of Agricultural Engineers at Purdue University in June. This is an ambitious program. It creates a golden opportunity to accelerate progress (1) in the direction of agricultural-engineering technology toward the fields of its greatest opportunity, (2) in the public relations of the profession, and (3) in the professional development of individual agricultural engineers.

To make the most of this opportunity, intensive forethought on the subject will be necessary. Those who hope to contribute to the discussion, or to listen intelligently in their own interest, will do well to begin now organizing their thoughts on the subject. By way of providing a starter, some food for thought, or at least a bone of contention, we offer the following.

The social aspects of agricultural engineering are obviously a phase of the social aspects of engineering in general. They are likewise complicated by economic relationships which serve as connecting links through which engineering causes produce social effects; and through which social needs stimulate engineering activity. These economic relationships are themselves not clearly understood and are a part of our current engineering-social problems.

For example, is it not true that one of the strongest influences of engineering on society has been its effect on the relationships between production and consumption? Has there been a satisfactory explanation of this social aspect of engineering?

The following elementary economic concepts may be said to be involved in production-consumption relationships:

1. Human wants are unlimited
2. Consumption to satisfy wants is the ultimate end of all production
3. Consumption, to be economic, must give satisfaction
4. Value is the relative consumer satisfaction an article or service is capable of giving, expressed in terms of what will be exchanged for it
5. Wealth is a store of value or anticipated consumer satisfaction
6. Income is produced value, in both an individual and a national sense

If these concepts are true, is it not also true that income is used in two ways, from the standpoint of production-consumption relationships—part reinvested in production activities, and part consumed to satisfy current wants? In other words, is it not a mathematical certainty that some percentage of our national income currently reinvested in production equipment will hold that production capacity in approximate balance with the consumption capacity of the remainder of the national income? And when more than this consumption-justified proportion of the national income is reinvested in production equipment, does it not defeat its purpose by decreasing consumption capacity a corresponding amount?

We seem to have found for this line of thought both corroboration and agricultural application in the following paragraph by Dr. J. Brownlee Davidson[1]:

> If the well-being of the farmer and his family is the present problem, how may the situation be improved? To me two things seem necessary: (1) The farmer must desire a higher standard of living, and (2) when the desire is present, he must have the income to realize that desire. If the income exists without the desire for a higher standard of living, well-being is not advanced because the extra income is used to increase competition within the industry and agriculture is overcapitalized.

What is the proportion of our national income which, if reinvested in production machinery, will hold our production capacity up to the consuming capacity of the remainder of the national income and provide for a healthy degree of competition, obsolescence, replacement, advancement, expansion to meet population increases, new wants, and new means of satisfying them? Do not our economic symptoms suggest that, among other mistakes, we may have been creating production capacity without reference to the proportion of our national income left to consume the products of that capacity? Is not this division of income with reference to production and consumption one social aspect of engineering which warrants further consideration, even by agricultural engineers?

[1] "The Philosophy of Agricultural Engineering," by J. Brownlee Davidson. AGRICULTURAL ENGINEERING, Vol 12, No 8 (August, 1931).

Just Between Ourselves

HERE'S a poser for agriculture's reactionaries, found in an official press release on the recent annual report of the Secretary of Agriculture for the fiscal year of 1932: "When farmers need to reduce their production, they should economize on land and labor, not in the use of improved practices. . . . Far from aggravating the surplus problem, scientific methods point the way to its solution by making production more dependable, and therefore more easily controlled."

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IN 1932 AGRICULTURAL ENGINEERING published the contributions of 92 authors, a total of 96 articles filling 225 pages. This compares favorably with the year 1930 when the contributions of 102 authors were given space. The Silver Anniversary Number published in June 1931 boosted the number of contributors to 129 for an otherwise comparable year. Most of the contributors are members of the American Society of Agricultural Engineers. Others are higher administrators and representatives of closely related fields.

These figures indicate in some measure the high proportion of A.S.A.E. members contributing to the growing literature of agricultural engineering, the breadth of viewpoint and experience brought to the attention of its members and other Journal readers, and the representative character of AGRICULTURAL ENGINEERING as "the technical journal of the American Society of Agricultural Engineers."

Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W. Trullinger, specialist in agricultural engineering, Office of Experiment Stations, U. S. Department of Agriculture. Requests for copies of publications abstracted should be addressed direct to the publisher.

Manifold Phenomena in Internal Combustion Engines, K J De Juhasz (Minnesota University [St Paul], Engineering Experiment Station Bulletin 7 [1930], pp VI + [39], illus 25).—The object of the experiments reported in this bulletin was to collect data relating to the pressure phenomena attending the exhaust and intake processes in high-speed internal-combustion engines and to evaluate data upon which the computation of the light-spring card may be based. Actual indicator cards were taken on several engines in the laboratory under different loads and speed conditions, and the results were evaluated from different points of view.

The report also contains a survey of methods used for determining a light-spring card for a given engine from the design data, and two original methods are described. By comparison of the recorded diagrams with those computed, it is shown that the actual conditions can be determined with a fair degree of approximation. It is also made evident that the accuracy may be increased by collecting more experimental data from different types of engines. In the actual experiments, 1, 4, and 12-cylinder engines were used.

In the studies of the pressure variation in the intake manifold, it was found that the mean manifold pressure gives imperfect information as to the pressure conditions in the manifold. It also was found that the pressure curves given by the two Venturi agree in form but differ in magnitude, indicating that the retransformation of velocity energy is far from being complete even in the case of a comparatively well-formed carburetor Venturi. The data on intake manifold pressures at different speeds show that the highest pressure in the intake manifold occurs later in the cycle as the engine speed increases. The maximum pressure obtained also increases with the speed up to a certain point.

The data on pressure drop caused by the carburetor Venturi show that the actual pressure drop in the manifold is far greater than the calculated value corresponding to the velocity in the intake pipe, and even exceeds that corresponding to the Venturi velocity. This is taken to indicate that the retransformation of velocity into pressure, while the combustible mixture passes through the Venturi into the intake pipe, take place with low efficiency. This means that any pressure regained is lost again owing to the change of direction of the flow in the bends, and friction of the manifold walls. It is concluded that taking simultaneous pressure readings at different points along the intake manifold would furnish valuable information as to where the pressure losses occur and would give a basis for the development of more efficient manifolds.

Studies of the determination of the flow of gas through manifolds resulted in complex mathematical analyses of the different factors involved, and produced the conclusion that the carburetor Venturi, as it is used in present day carburetors, is a velocity-pressure transformer of very low efficiency.

The results in general indicate the desirability of extending the studies to static and dynamic pressures at several points of the intake and exhaust systems of one- and multi-cylindered engines.

The Artificial Drying of Forage Crops, O Schnellbach ([International Review of Agriculture] Monthly Bulletin of Agricultural Science and Practice [Rome], 22 [1931], No 11, pp 436-438).—In a contribution from the Reichskuratorium fur Technik in der Landwirtschaft, a summary is given of results of studies from various sources on the artificial drying of forage crops. It is pointed out that driers used only as a protection against bad weather can not be profitable.

Moisture: Its Influence on the Heat Conductivity of Building Materials, A A Berestneff (Heating and Ventilating [New York], 29 [1932], No 4, pp 27-32, figs. 7).—Data are reported leading to the conclusion that all tables for coefficients of heat conductivity of structural materials should also indicate the moisture content at which the conductivity values were established. It has been found that a high moisture content may increase and even double the heat losses, as indicated by the coefficients now in use.

Moisture Penetration in Exterior Walls, H A Gray (Journal of the Boston Society of Civil Engineering, 19 [1932], No 3, pp 110-136).—Data are presented from an investigation of the factors affecting the construction of a satisfactory exterior masonry wall including only those portions of the wall which are above ground. No conclusions are drawn, but a large number of practical suggestions are presented.

Handbook of Farm Machinery Technic, Vol II, No 1, G Kuhne (Handbuch der Landmaschinentechnik Berlin: Julius Springer, 1932, vol 2, No 1 pp IV + 264, pl 1, figs 720).—This is part 1 of the second volume of information on the technology of German agricultural machinery which the author has prepared on the basis of his long experience at the Technical Academy of Munich. It is devoted to a profusely illustrated technical discussion of harvesting, threshing, and grain cleaning and sorting machinery.

Sections are included on mowers with and without grain-binding attachments; haying machinery, including tedders and rakes; potato and sugar-beet digging and topping machinery; threshing machines, including combines; and machines for cleaning and grading grain and potatoes.

In connection with the potato and beet-harvesting machines the results of some investigations on the more recent improvements and developments are summarized, including draft tests of beet lifters, toppers, and grubbers.

Tests of Gas Home-Heating Equipment, R B Leckie and C H B Hotchkiss (Purdue University [La Fayette], Engineering Experiment Station Research Service 36 [1931], pp 166, pls 9, figs 8).—Investigations are reported in this bulletin, the purpose of which was to secure data indicating the heat-absorption efficiencies which can be obtained from some of the leading types of gas conversion units when tested under laboratory conditions. A gas-designed boiler was included in the tests to provide a standard for the evaluation of the tests on conversion burners. Tests also were made on one solid-fuel boiler using five different conversion burners. Two power-driven gas conversion units were tested one of which made use of refractory material and of the principle of surface combustion, while the other had no refractory but allowed the gas-air mixture to burn close to the wall of the furnace. Two units of the Bunsen type were also selected. A fifth unit tested was of the jet type.

The test work involved both constant and intermittent operation. The conversion burners were tested under both methods, and similar tests were conducted on gas-designed boilers. Apparently an increase in thermal efficiency may be expected when proper baffling is inserted in a boiler. However, the need for baffling is dependent on the design of the boiler, and no improvement can be expected in the design of conversion burners that will take care of this feature. It also was found that efficiency was raised approximately 2 per cent by insulating the boilers. Increasing the stack draft increased the percentage of oxygen in the flue gases and reduced the efficiency of the plant. It appears that an approximate reduction of 1 per cent in thermal efficiency of the boiler may be expected for each per cent increase of oxygen in the stack gas.

It was found that boilers designed for solid fuel gave about as good results with reference to efficiency as gas-designed boilers. It also was found that the use of an over-size boiler is not necessary to secure high efficiency with a conversion burner. The conclusion is drawn that a conversion burner, if properly installed in an efficient domestic steam boiler, will operate with good absorption efficiency. Under constant operation high thermal efficiencies were obtained with the conversion burners operating in boilers of different sizes and dissimilar in construction.

Experiments with Farm Machinery (Canada Experiment Farms [Ottawa], Report Directory 1929, pp 20, 21, fig 1).—Results of experiments are reported on the use of the combined corn binder and silage cutter and with weed control machinery. It was found that the combined corn binder and silage cutter requires a fairly large acreage of corn to justify its operation, and it can not be used to ensile such crops as oats or sweet-clover.

[Agricultural Engineering Investigations at the Virginia Station] (Virginia Station [Blacksburg] Report 1928-1931, pp 58-62, fig 1).—In studies of tractor cultivation of row crops, trials of the rotary hoe for the cultivation of corn indicated that this implement was adapted to the earlier cultivations of corn because it moved rapidly and damaged the plants no more than does the ordinary row cultivator. The hoes should be sufficiently spaced to prevent the wedging of stones or sticks between the hoes.

Trials of the old style malleable-iron rotary hoe and of the new flexible-frame steel hoe in corn cultivation in a field containing old stumps showed that the old style rigid-frame hoe passed over the stumps with greater ease than did the flexible-frame hoe but in doing so left more land untilled. The flexible-frame steel hoe adapts itself more easily to the irregularities of topography. The damage to the crop was small with either hoe. The best work is done with hoes operated at a speed of 3 miles per hour.

In plowing tests it was found that the one-way plowing disk and the so-called "Big-Bill" plowing disk are not desirable where deep plowing is required for corn on rolling topography. The pulverator was very satisfactory for this purpose.

Tests of the combine for harvesting grain and soybeans under Virginia conditions, made in cooperation with the U S D A

Bureau of Public Roads, showed that the combine harvested rye and wheat satisfactorily at a total cost of $3.10 per acre, which is a saving of about $1.50 per acre over the usual binder and thresher method.

In harvesting soybeans, the combine gave an average loss of only 11.5 per cent of the seed as compared with a loss of about 35 per cent when soybeans are harvested with row harvesters or cut with a mower. Mechanical features which were found desirable to adapt the combine to Virginia conditions for harvesting soybeans were (1) a flexible or floating cutting-bar capable of cutting within 4 in of the ground, (2) a cylinder-speed reduction to 450 or 500 rpm to prevent excessive splitting of beans, and (3) the separating mechanism should be kept at normal speed.

Tests of the general-purpose tractor in the cultivation of corn, potatoes, and other crops showed that desirable features of a tractor cultivator include (1) flexibility in both lateral and longitudinal directions for successful operation on rolling, hilly, terraced, and irrigated land, (2) easy attaching and detaching of cultivator from tractor, (3) provision for cultivating tractor-wheel tracks, (4) ability to control tractor and cultivator with steering gear alone, and (5) ability to lift cultivator with one lever.

Data are also reported from household-engineering and water-heating studies and from electric-iron tests.

[Agricultural Engineering Investigations at the Texas Station], H. P. Smith, D. T. Killough, D. Scoates, D. L. Jones, B. H. Hendrickson, R. W. Baird, B. V. Geib, and H. O. Hill (Texas Station Report 1931, pp. 96-98, 113-116, 133, 134).—The progress results are briefly presented of studies on the mechanical harvesting of cotton, factors of efficiency in the distribution and placement of cottonseed and fertilizer, soil erosion, types of terraces, soil erosion prevention and moisture conservation by strip cropping, strip subsoiling and terracing, and run-off in relation to soil erosion. The work on soil erosion and related features is being conducted in cooperation with the U.S.D.A. Bureaus of Agricultural Engineering and Chemistry and Soils.

The Saturation Pressure of Engine Fuel and a New Method for Its Determination [trans. title], Wawrzinick (Automobiltech. Zeitschrift, 34 (1931), No. 28, pp. 653, 654, fig. 1; 31, pp. 724-726, figs. 5).—A new method and apparatus for measuring the saturation pressure of liquid fuels for use in internal-combustion engines in relation to temperature is described and illustrated, and experiments with different fuels are reported.

The saturation pressures of light, medium, and heavy benzines showed wide differences. The light benzine requires only a little preheating owing to its high saturation pressure and low surface tension, whereas the medium and heavy benzines with lower saturation pressures require more preheating.

Experiments on the effect of mixing fuels on the saturation pressure showed that the saturation pressures of mixtures as well as the temperatures of vaporization combined the properties of the mixed liquids through which the former was raised and the latter lowered. The same result was obtained by adding alcohol to pure benzol in the proportions of 40 per cent of the former to 60 per cent of the latter, in spite of the low saturation pressure of the alcohol. This was especially true at higher temperatures.

The conclusion is drawn that the addition of alcohol to benzol and benzine is not only not injurious but improves these fuels for use in internal-combustion engines.

German Farm Wagons, J. Balkenholl (Deutsche Ackerwagen. Berlin: Deutsche Landbuchhandlung, [1932], pp. IV+154, illus. 37).—This is a treatise on farm wagons as they are used in German agriculture.

Studies of the adaptation of wagons to specific requirements led to the conclusion that where they are drawn by animals the diameter of the wheels should be as large as possible and the wheel rims as broad as possible consistent with other features of construction, also that the track should be as wide as possible. The diameter of the axles should be reduced to the minimum. The wagon bed should be relatively narrow with reference to the wheel track width to allow ease in turning. The total weight of the wagon should be reduced to the minimum consistent with the load to be hauled.

The different types of wagons used in German agriculture are described and their uses for different purposes discussed.

Fertilizer Distribution with Different Machines [trans. title], L. Tinnefeld (Zuckerrubenbau, 13 (1931), No. 12, pp. 197-202, figs. 8).—Experiments on the distribution of artificial fertilizers in soil by different tillage machines are reported. Harrowing once and twice placed some of the fertilizer at a depth of 3 in, although the major portion remained at a depth of only 1.5 in. Cultivation to a depth of 6 in placed some of the fertilizer 4.75 in deep, although half of it still remained at a depth of 1.5 in.

Scarification produced complete uniform distribution of the fertilizer throughout the seedbed. However, the process proved expensive and impractical especially in stony soils.

Plowing gave the best practical results in fertilizer distribution. Plowing at a depth of 12 in using a jointer placed most of the fertilizer at a depth varying from 6 to 12 in. Without the jointer the fertilizer was placed at a depth varying from 4 to 10 in with very little left in the surface layer of soil.

The best fertilizer distribution and mixing with soil was obtained by cultivating to a depth of 9.5 in. When a subsoil fertilizer plow was used, the fertilizer was placed at a depth of from 13 to 15 in.

First Report of the Steel Structures Research Committee, C. D. M. Hindley et al. (London: Department of Science and Industrial Research, 1931, pp. XII + 276, pls. 15, figs. [111]).—This report reviews present methods and regulations for the design of steel structures, brings together the results of investigations of the application of the modern theory of structures to the design of steel structures, and presents recommendations for the practical use of such of the results as would appear to lead to more efficient and economical design.

Forest and Stream Flow, W. G. Hoyt and H. C. Troxell (American Society of Civil Engineers [New York, N. Y.] Proceedings 58 (1932), No. 6, pp. 1037-1066, figs. 9).—This paper brings together and analyzes the results of investigations from various sources on the effect on stream flow of changes in forest and brush cover on specific natural areas.

An experiment by the U.S.D.A. Forest Service and Weather Bureau was conducted from 1910 to 1926 on two contiguous tracts of land in southern Colorado. Streamflow measurements by the U. S. Geological Survey in cooperation with the state of California and the county of Los Angeles were begun in 1916 on certain areas in California, on some of which accidental denudation by burning afforded opportunity for comparisons. Detailed observations were made in both these areas for several years before changes in cover were accomplished by cutting and by fire and were continued for several years after such changes.

With reference to total run-off it was found that forests did not conserve the water supply, because after their removal there was an increase in average annual yield amounting to 15 per cent in a mountain area in Colorado and 29 per cent in a southern California coastal mountain area. Contrary to the widely quoted opinion the increase in run-off is not confined wholly to flood periods. In both the Wagon Wheel Gap area and in the southern California area 52 per cent of the increase occurred during the non-flood period. The flow during the non-flood period is derived from subsurface storage. The increase during non-flood periods results from either increased subsurface flow and storage, or decreased transpiration, or a combination of both.

In the Wagon Wheel Gap area there was an average increase of 46 per cent in maximum daily discharge after deforestation, due to increased subsurface flow. In the southern California area the four storms occurring during the first year after the fire resulted in an increase of 1,700 per cent in the maximum daily discharge. The removal of vegetative covering clearly increases normal flood height. It is concluded to be a fallacious belief that forests or vegetative covering will increase summer run-off and shorten the low-water period through the exercise of storage functions.

Coincident with the increase in summer run-off there was an increase in the average summer minimum, and the period of low-water run-off was considerably shortened. In the Wagon Wheel Gap area the average minimum was increased about 12 per cent and the time of occurrence delayed about 5 days. In the southern California area the average minimum was increased more than 400 per cent, and the time of occurrence was delayed about 30 days. Deforestation made no appreciable change in the low flows which occurred during the winter in the Wagon Wheel Gap area where there was practically no evidence of erosion after deforestation, because there was little direct surface run-off either before or after deforestation. In the southern California area complete denudation increased erosion as a direct result of the increased surface run-off.

The conclusion is drawn that in basins where shortages in water supply are becoming critical or where abnormal expenditures have been made to augment water supplies, the maintenance of forests or reforestation for the conservation of water supply may have an effect exactly opposite to that desired.

Investigations on Lubrication [trans. title], O. Walger (Zeitschrift des Vereines Deutscher Ingenieure [Berlin], 76 (1932), No. 9, pp. 205-208, figs. 5).—Studies conducted at the Technical Academy of Karlsruhe on the hydrodynamic theory of friction bearings are reported in which viscosity of lubricant, load, speed of journal, and bearing clearance were varied.

It was found that in the region of semifluid friction a strong influence of absorption between lubricant and bearing surface is felt. The character of the added lubricant also had an important influence. When conditions of semifluid friction prevailed the addition of colloidal graphite to the lubricant decreased the friction values markedly.

Preliminary experiments with new synthetic lubricants which contain no oil or fat gave favorable friction values.

The results in general showed that the hydrodynamic theory is applicable to conditions of fluid friction, but that the limits of semifluid friction must be recognized and accounted for because oil properties other than viscosity are of essential importance in that region.

Bearing Lubrication, A. S. T. Thomson (Journal of the Royal Technical College [Glasgow], 2 (1932), No. 4, pp. 638-656, figs. 12).—The results of experiments with an oil ring bearing are

reported, and a method of measuring oil film thickness is described. During the experiments the effects of variations in load, speed, and temperature were observed on the value of the coefficient of friction, and a series of tests were conducted with four standard automotive engine lubricating oils.

The bearing machine consisted essentially of a double ring oiler bearing 5.0 in long and a load carriage mounted on a 2.5-in shaft. The bearing pressure is varied by a set of movable weights, and the machine is driven in either direction by means of a variable gear. The loaded half of the bearing is bedded to the shaft over an arc of about 120 deg.

It was found that as the load is applied on the top of the bush the slits for the oil rings are on the loaded side of the brass. This is rather a serious defect as the oil is being fed to the journal at the point of maximum pressure. The result is a tendency to poor lubrication at high loads. Throughout the tests this is evident, as at high loads a sudden abnormally large reading of friction torque may be obtained indicating a state of semi-boundary or greasy lubrication. These occasional false readings are obviated by moving the loaded bearing backward and forward along the shaft before taking a reading, thus ensuring the formation of a viscous oil film.

With the circular loads in position on the bottom carrier, the center of gravity of the system is lowered and hence the machine is not so sensitive to a small addition in the friction torque weights. Higher bearing pressures could have been obtained by a system of levers. The existing bearing is not suitable for the insertion of several thermocouples due to the position of the ring slits and projections in the bearing housing. A reversing gear would be an advantage, as it would considerably speed up the taking of readings at low speeds.

The machine is not sufficiently rigid for accurate oil film thickness determinations. For attitude and eccentricity determinations a very short rigid shaft, 5 in in diameter with bearings 12 in apart, would be more suitable. The experimental values of the coefficient of friction obtained appeared to be rather large for conditions of pure fluid friction.

The four standard lubricating oils were tested in the experimental bearing machine and also in a Deeley oiliness machine and in a Boult oil tester, the last being used for an endurance test. The oils showed no great difference in viscosity and sufficiently low-pour points for normal working conditions. On being tested for oiliness after heating to 200 deg F and cooling, no change was apparent in the static friction of any of the oils.

There was some variation in the loss of efficiency of the four oils after use, which it was found was not due to high temperature alone. This was attributed not only to the intermingling of grit and dust with the oils but to the partial oxidation of the organic portion of the oil, due to rapid shearing at high temperature. It also was found that at low temperatures the coefficients of friction varied approximately with the viscosities of the oils. The speed required to reach the minimum value of the coefficient of friction varied to some extent with the oiliness factor of each oil.

Progress Report on Draft of Plows Used for Corn Borer Control, W. Ashby, I. F. Reed, and A. H. Glaves (U.S.D.A. Bureau of Agricultural Engineering [Washington] 1932, pp. 23 + [7], figs. 11).—A series of plow draft tests is described the purpose of which was to develop methods for more conclusive studies.

Draft records of 25 plows were obtained in the fall of 1928. An oil-cylinder type of recording dynamometer and medium-weight wheel tractor with spade lugs were used, and records were made at both 6 and 8-in depths. Each plow at each round crossed plats which had been single-disked, double-disked, and rolled with soil packer, as well as one to which no treatment had been given. The corn had been picked with a tractor-drawn mechanical corn picker. Usable draft records were secured for 22 plows at 6-in depth and for 21 plows at 8-in depth. The average distance traveled in making each record was about 2,000 ft. Ten plows were tested at 6-in depth at two rates of travel, 2.5 and 3.25 mph. In all tests the plows were equipped with standard rolling coulters, jointers, and covering wires.

During June and July, 1931, a group of 158 variable speed draft tests were run in a clay loam soil. The field was last plowed during the spring of 1927. No crop was put in that season or since.

A number of comparative tests to obtain information about the effect of plow attachments on the draft; relative draft of 1, 2, and 3-bottom plows; draft of plows of various sizes, and effects of disking, double disking, etc., on draft were made in the spring of 1928 on sandy loam and clay loam soils using an Iowa integrating dynamometer. These tests were made in cornfields from which the stalks had been removed, leaving an 8-in stubble.

It was found that a close relationship exists between soil moisture and plow draft. The data indicate the great importance of plowing when soil conditions are right and suggest how quickly these conditions may become unfavorable after rains. It appears from the data presented that reduction in draft within the moisture range represented by these tests—probably 15 to 25 per cent—takes place as the result of the loosening of the moisture films rather than from changes in friction.

It seems clear that working clay loam soils with tractor-drawn implements, when damp or moist, causes a net increase in draft, though this did not appear to be the case in the field that was worked when dry. After making allowance for side-draft and weight of plow it seems probable that at least half of the differences in draft are due to packing of the soil by the tractor.

The data also show that an increase in weight of plow from 3 lb per square inch of furrow slice to 5 lb per square inch increased the draft by 3.5 per cent, or, based on the average draft in this field, the draft due to weight alone increased at the rate of 0.185 lb per pound of total weight, which is relatively small. A rear wheel giving full support reduced the draft about 7 per cent as compared with a similar plow having no rear wheel.

No general tendencies in shape of points were found to satisfactorily explain variations in the draft. There appeared to be a well-marked relationship between draft and slope of moldboard at the mid-section, those plows having the steeper slope in proportion to their size showing the heavier drafts. There was no conclusive evidence as to other factors that influence draft. The analysis does not show that size of plow bottom has much effect on draft. However, the data are complicated by the use of coulters and jointers on the plows.

The studies of the effect of 6 and 8-in depths of plowing on draft showed that soil resistance was slightly higher at the end of the field where the 6-in tests were made. The 18-in plows were slightly more efficient for deep plowing than the 16 or 14-in plows. The data also indicate that under uniform soil conditions an increase of 33 per cent in depth (from 6 to 8 in) resulted in an increase in draft of only 14 or 16 per cent.

In the tests of the effect of speeds of 2.5 and 3.25 mph on draft it was found that the average draft of the whole group showed an increase of 8.6 per cent at the higher speed, and the average of the 14-in group showed a 10.6 per cent increase. The average increase in draft with the two bottoms used was 1.17 lb per square inch of furrow slice for each mile per hour increase in speed.

The use of two 10-ft covering wires increased the draft about 2 per cent. Other tests indicated that three wires pull very little harder than two since they usually wrap together and pull through the soil as a unit. It appears that the ordinary jointer used for corn borer control absorbs about 7 per cent of the power when used with the coulter, and that the use of the jointer alone requires less power than the coulter and jointer together. It seems probable that coulter, jointer, and wires together absorb between 10 and 15 per cent of the total power.

Soft Water for the Home, A. M. Buswell and E. W. Lehmann (Illinois Agricultural Experiment Station [Urbana] Circular 393 (1932), pp. 16, figs. 6).—This circular presents practical information on how to secure an adequate supply of clean rain water, how to soften well water in cisterns, and on the use of a zeolite water softener.

Plowing with Moldboard Plows, W. Ashby and A. H. Glaves (U. S. Department of Agriculture [Washington] Farmers' Bulletin 1690 (1932), pp. II + 22, figs. 16).—This bulletin is based upon studies of plowing conducted jointly by the Bureau of Agricultural Engineering and the Plant Quarantine and Control Administration in cooperation with the Bureau of Entomology. Its purpose is to present information which will aid in keeping moldboard plows in good working condition, in using them most effectively, and in selecting new equipment to replace old.

Land Drainage, W. L. Powers and T. A. H. Teeter (New York: John Wiley & Sons; London: Chapman & Hall, 1932, 2. ed., rev. and enl., pp. X + 353, figs. 169).—This is the second, revised, and enlarged edition of this book. It consists of four parts, dealing with field drainage, district drainage, special drainage problems, and drainage surveying. It takes into account the advances made in the decade since the first edition relating to river and flood control, soil erosion and terracing, use of explosives in drainage and clearing, drainage by pumping from wells, vertical drainage, and the development of pumping machinery and ditch building methods. Appendixes contain farm drainage laboratory exercises, tables for use in Kutter's formula, and the United States Census of drainage for 1930.

Twenty-five Years of Supplemental Irrigation Investigations in Willamette Valley, W. L. Powers (Oregon Agricultural Experiment Station [Corvallis] Bulletin 302 (1932), pp. 30, figs. 14).—The results of 25 years of experiments with supplemental irrigation in the Willamette Valley are summarized.

It has been found that the normal rainfall in the valley from May 1 to October 1 is 5.43 in, whereas the loss by evaporation from a Weather Bureau tank averaged 26.615 in for the same period.

Soil and ground water surveys of the valley indicate that more than one-half million acres of naturally drained and free-working soil are well situated and suitable for irrigation for diversified crops, while nearly another half million acres with less perfect drainage are fairly suitable for irrigation for pasture or forage crops.

The crops found to give best response to supplemental irrigation are the small fruits and truck crops, those crops grown for intensive dairying such as pasture and late cuttings of legume crops, or row crops that make maximum growth late in the season, such as roots and corn. Potatoes and beans are cash crops that give large returns from small amounts of irrigation.

(Continued on page 30)

A.S.A.E. and Related Activities

The Pacific Coast Section Program

THE Pacific Coast Section of the American Society of Agricultural Engineers, as previously announced, will hold its eleventh yearly meeting at the Hotel Sainte Claire, San Jose, California, with Russell L. Perry, chairman of the Section, presiding. The meeting will be called to order at 10:00 a.m., and opened with a short address by the chairman. The other features of the forenoon session will consist of two technical papers: "Practical Application of Electric Soil Heating," by P. F. Leverenz, agricultural engineer, Pacific Gas and Electric Company, and "The Dielectric Property of Water as a Basis for Measuring the Quantity of Water in Materials," by N. E. Edlefsen, irrigation engineer, University of California.

Directly following the luncheon hour, the Section will hold a business session for the election of officers, for the presentation of committee reports, and for other business, including plans which the Section is formulating for the occasion of its acting as host to the parent Society when it holds its 28th annual meeting at Asilomar, California, in June 1934.

The technical program for the afternoon session includes a number of subjects, as follows: "The Application of Insecticides," by H. C. Lassen, field manager, John Bean Manufacturing Company; "Accidents in Agriculture," by C. H. Fry, superintendent of safety, Industrial Accident Commission (San Francisco); "Precooling of Agricultural Products," by J. C. Rear, Eng. Union Ice Company (San Francisco), and "Low Pressure Tires for Agricultural Equipment," by J. L. Puckett, Firestone Tire and Rubber Company.

The technical program of the day's sessions will be followed by a dinner in the evening, with Chairman Perry as master of ceremonies. Following the dinner a talk, entitled "Recollections from the Hubbard Alaskan Expedition," will be given by Father P. F. Galtes, professor of chemistry and geology, Santa Clara University.

Southern Section Meeting in February

THOUGH not available as this number of AGRICULTURAL ENGINEERING goes to press, the program for the meeting of the Southern Section of the American Society of Agricultural Engineers next month is rapidly taking final form. The meeting, as previously announced, will be held at New Orleans, February 1, 2, and 3, in connection with the annual meeting of the Association of Southern Agricultural Workers.

The central theme of the general program of the A.S.A.W. meeting is to be "Economics as Applied to Rural Life." The program of the A.S.A.E. Southern Section is being planned to fit into this theme, and will feature especially the economics of farm production.

One of the features of the meeting will be practically an entire half-day session devoted to the subject of agricultural-engineering extension. Those contributing to this program are all agricultural extension engineers, connected with land-grant institutions of the South, and their respective subjects will be presented largely from the economic point of view.

Another half-day session will be devoted to the consideration of a soil erosion control program, a subject of particular interest and importance to the agriculture of the South.

Necrology

AUSTIN BENJAMIN CRANE passed away at his home at Everett, Washington, on December 8. He was born at Fond du Lac, Wisconsin, in 1864, and held both a bachelor's and a master's degree in civil engineering from South Dakota State College. Upon graduation he was employed by his alma mater as assistant instructor in mathematics, and from 1901 to 1906 he served the institution as professor of agricultural engineering. The following eight years he was engaged in private practice as an irrigation engineer, but in 1914 he associated himself with Spokane University (Washington) as professor of mathematics and civil engineering. In 1918 he was appointed extension specialist in agricultural engineering at the State College of Washington, specializing in drainage and irrigation engineering, water supply, farm power, and sanitation. During recent years and until his passing, Mr. Crane has been engaged in professional agricultural engineering practice.

ASAE Personals

Earl D. Anderson and **Henry Giese** are joint authors of Bulletin No. 296, entitled "Rural Fire Waste in Iowa, 1930-31," recently issued by the Iowa Agricultural Experiment Station.

Fred A. Lyman has recently joined the staff of the Portland Cement Association, Chicago.

New ASAE Members

W. J. Gillespie, Jr., R.F.D. No. 1, Tazewell, Va.

Cadwallader W. Kelsey, president, Rototiller, Inc., Long Island City, N. Y.

Wm. B. Nivison, graduate assistant in agricultural engineering, University of Minnesota, St. Paul, Minn.

Geo. B. Nutt, associate professor of agricultural engineering, Clemson College, Clemson College, S. C.

Hugh D. Sexton, graduate assistant, agricultural engineering department, Alabama Polytechnic Institute, Auburn, Ala.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the December issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

W. E. Ayres, assistant director in charge, Delta Experiment Station, Stoneville, Miss.

Joseph H. Flanagan, lubricating engineer, Standard Oil Company, 910 South Michigan Ave., Chicago, Ill.

F. E. Hardisty, associate agricultural engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture. (Mail) Box 413, Zanesville, Ohio.

Geo. W. Pickering, sales manager, The Cleveland Tractor Co., Cleveland, Ohio.

Arthur H. Senner, mechanical engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture, Washington, D. C.

Clarence F. Vogel, Lark, N. Dak.

Transfer of Grade

C. F. Miller, agricultural engineer, National Lumber Manufacturers Association, Room 2017, Conway Building, Chicago, Ill. (Associate Member to Member)